Positive Displacement Pumps—Rotary

API STANDARD 676
THIRD EDITION, NOVEMBER 2009

REAFFIRMED, MARCH 2015

energy API
AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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Introduction

This standard is based on the accumulated knowledge and experience of manufacturers and users of rotary positive displacement pumps. The objective of this standard is to provide a purchase specification to facilitate the procurement and manufacturer of rotary positive displacement pumps for use in petroleum, chemical, and gas industry services.

The primary purpose of this standard is to establish minimum requirements. This limitation in scope is one of charter as opposed to interest and concern.

Energy conservation is of concern and has become increasingly important in all aspects of equipment design, application, and operation. Thus innovative energy conserving approaches should be aggressively pursued by the manufacturer and the user during these steps. Alternative approaches that may result in improving energy utilization should be thoroughly investigated and brought forth. This is especially true of new equipment proposals, since the evaluation of purchase options will be based increasingly on total life costs as opposed to acquisition cost alone. Equipment manufacturers, in particular, are encouraged to suggest alternatives to those specified when such approaches achieve improved energy effectiveness and reduced total life costs without sacrifice of safety or reliability.

This standard requires the purchaser to specify certain details and features. Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of this standard, it is strongly recommended that such modifications, deletions, and amplifications be made by supplementing this standard, rather than by rewriting or incorporating sections thereof into another standard.

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Positive Displacement Pumps—Rotary

1 Scope

This standard covers the minimum requirements for rotary positive displacement process pumps and pump units for use in the petroleum, petrochemical, and gas industry services. Controlled-volume pumps, hydraulically driven pumps and positive displacement reciprocating pumps are not included (see API 674 for positive displacement reciprocating pumps and API 675 for controlled-volume pumps).

For rotary positive displacement pumps in auxiliary services (e.g. lube oil systems), manufacturer's standard with demonstrated experience is acceptable.

Annex A contains datasheets which purchasers are encouraged to use (informative).

Annex B provides guidance for factors affecting twin screw efficiencies (informative).

Annex C contains an inspector's checklist (informative).

Annex D contains forms which may be used to indicate vendor drawing and data requirements (VDDRs) (informative).

Annex E gives guidance regarding net positive suction head (NPSH) vs net positive inlet pressure (NPIP) (informative).

Annex F gives guidance on pulsation and vibration control techniques (informative).

Annex G provides a typical piping and instrumentation diagram for multiphase pump (MPP) skids (informative).

This standard requires the purchaser to specify certain details and features. A bullet (●) at the beginning of a paragraph indicates that either a decision by, or further information from, the purchaser is required. Further information should be shown on the datasheets (see example in Annex A) or stated in the quotation request and purchase order.

2 Normative References

2.1 The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Specification 5L:2007/ISO 3183 [1], *Specification for Line Pipe*

API Recommended Practice 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*

API 500A, *Classification of Locations for Electrical Installations in Petroleum Refineries* (superceded by API 500)

API Recommended Practice 520:2000, *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries; Part I—Sizing and Selection*

[1] International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.

API Recommended Practice 520:2003, *Sizing, Selection, and Installation of Pressure-relieving Devices in Refineries; Part II—Installation*

API Standard 526:2002, *Flanged Steel Pressure Relief Valves*

API Standard 541:2004, *Form-wound Squirrel-cage Induction Motors—500 Horsepower and Larger*

API Standard 546:1997, *Brushless Synchronous Machines—500 kVA and Larger*

API Standard 547:2005, *General-purpose Form-wound Squirrel-cage Induction Motors—250 Horsepower and Larger*

API Recommended Practice 578, *Material Verification Program for New and Existing Alloy Piping Systems*

API Standard 611:2008, *General-purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*

API Standard 613:2003, *Special Purpose Gear Units for Petroleum, Chemical, and Gas Industry Services*

API Standard 614/ISO 10438, *Lubrication, Shaft-sealing, and Control-oil Systems and Auxiliaries*

API Standard 670:2003R (Reaffirmed), *Machinery Protection Systems*

API Standard 671/ISO 10441, *Special Purpose Couplings for Refinery Services*

API Standard 676, *Positive Displacement Pumps—Rotary*

API Standard 677:2000R, *General-Purpose Gear Units for Petroleum, Chemical and Gas Industry Services*

API Standard 682:2004/ISO 21049, *Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps*

API Recommended Practice 686:1996, *Machinery Installation and Installation Design*

ABMA 7:2001 [2], *Shaft, Housing Fits for Metric Radial Ball and Roller Bearings (Except Tapered Roller Bearings) Conforming to Basic Boundry Plans*

ABMA 9:2000, *Load Ratings and Fatigue Life for Ball Bearings*

AGMA 2015-1:2001 [3], *Accuracy Classification System—Tangential Measurements for Cylindrical Gears*

AGMA 6010:2003, *Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives*

AGMA 6013:2006, *Standard for Industrial Enclosed Gear Drives*

AGMA 6091, *Standard for Gearmotor, Shaft Mounted and Screw Conveyor Drives*

AGMA 9000:2001, *Flexible Couplings—Potential Unbalance Classification*

AGMA 9002:2001, *Bores and Keyways for Flexible Couplings (Inch Series)*

ASA S2.19:1999 [4], *Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1: Determination of Permissible Residual Unbalance, Including Marine Applications*

[2] American Bearing Manufacturers Association, 2025 M Street, NW, Suite 800, Washington, DC 20036, www.abma-dc.org.
[3] American Gear Manufacturers Association, 500 Montgomery Street, Suite 350, Alexandria, Virginia 22314, www.agma.org.
[4] American Subcontractors Association, 1004 Duke Street, Alexandria, Virginia 22314, www.asaonline.com.

ASME *Boiler and Pressure Vessel Code* (*BPVC*) [5], *Section V-2001: Non-destructive Examination*

ASME *BPVC*, *Section VIII-2001: Pressure Vessels; Division 1*

ASME *BPVC*, *Section IX-2001*: *Welding and Brazing Qualifications*

ASME B1.1:2003, *Unified Inch Screw Threads (UN and UNR Thread Form)*

ASME B1.20.1:2006, *Pipe Threads, General Purpose (Inch)*

ASME B16.1:1998, *Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125 and 250)*

ASME B16.5:2003, *Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard*

ASME B16.11:2001, *Forged Fittings, Socket Welding and Threaded*

ASME B16.20:2004, *Metallic Gaskets for Pipe Flanges—Ring-joint, Spiral-wound and Jacketed*

ASME B16.42:1998, *Ductile Iron Pipe Flanges and Flanged Fittings*

ASME B16.47:1996, *Large Diameter Steel Flanges*

ASME B17.1:2003, *Keys and Keyseats*

ASME B31.3:2006, *Process Piping*

AWS D1.1:2003 [6], *Structural Welding Code—Steel*

DIN 910:2004 [7], *Heavy-duty Hexagon Head Screw Plugs*

EN 287:1997 [8], *Qualification Test of Welders—Fusion Welding*

EN 288:1997, *Specification and Approval of Welding Procedures for Metallic Materials*

EN 953:2003, *Safety of Machinery—Guards—General Requirements for the Design and Construction of Fixed and Movable guards*

EN 1759-1, *Flanges and Their Joints—Circular Flanges for Pipes, Valves, Fittings and Accessories, Class Designated—Part 1: Steel Flanges NPS 1/2 to 24*

EN 13445:2002, *Unfired Pressure Vessels*

HI 3.1-3.5 [9], *Rotary Pump Standards for Nomenclature, Definitions, Applications and Operation*

HI 3.6, *Rotary Pump Test*

IEC 60079 [10], *Explosive Atmospheres*

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5 ASME International, 3 Park Avenue, New York, New York 10016-5990, www.asme.org.
6 American Welding Society, 550 NW LeJeune Road, Miami, Florida 33126, www.aws.org.
7 Deutsches Institut für Normung E.V., Burggrafenstrasse 6, 10787 Berlin, Germany, www.din.de.
8 European Committee for Standardization, Avenue Marnix 17, B-1000, Brussels, Belgium, www.cen.eu.
9 Hydraulic Institute, 9 Sylvan Way, Parsippany, New Jersey 07054, www.pumps.org.
10 International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211, Geneva 20, Switzerland, www.iec.ch.

IEEE 841:2001 [11], *Standard for Petroleum and Chemical Industry—Severe Duty Totally-enclosed Fan-cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 Kw (500 Hp)*

ISO 7:1994, *Pipe threads where pressure-tight joints are made on the threads—Part 1: Dimensions, tolerances and designation*

ISO 7:2000, *Pipe threads where pressure-tight joints are made on the threads—Part 2: Verification by means of limit gauges*

ISO 228-1:2000, *Pipe threads where pressure-tight joints are not made on the threads—Part 1: Dimensions, tolerances and designation*

ISO 261:1998, *ISO general-purpose metric screw threads—General plan*

ISO 262:1998, *ISO general-purpose metric screw threads—Selected sizes for screws, bolts and nuts*

ISO 724:1993, *ISO general-purpose metric screw threads—Basic dimensions*

ISO 965:2000, *ISO general-purpose metric screw threads—Tolerances*

ISO 1940-1:2003, *Mechanical vibration—Balance quality requirements for rotors in a constant (rigid) state—Part 1: specification and verification of balance tolerances*

ISO 3448:1992, *Industrial liquid lubricants—ISO viscosity classification*

ISO 3744:1994, *Acoustics—Determination of sound power levels of noise sources using sound pressure—Engineering method in an essentially free field over a reflecting plane*

ISO 5753:1991, *Rolling bearings—Radial internal clearance*

ISO 6708:1995, *Pipework components—Definition and selection of DN (nominal size)*

ISO 7005-1:1992, *Metallic flanges—Steel flanges*

ISO 7005-2:1998, *Metallic flanges—Cast iron flanges*

ISO 8501-1:1988, *Preparation of steel substrates before application of paints and related products—Visual assessment of surface cleanliness—Part 1: Rust grades and preparation grades of uncoated steel substrates after overall removal of previous coatings*

ISO 10441:2007, *Petroleum, petrochemical and natural gas industries—Flexible couplings for mechanical power transmission—Special-purpose applications*

ISO 14120:2002, *Safety of machinery—Guards—General requirement for the design and construction of fixed and movable guards*

ISO 14691, *Petroleum, petrochemical and natural gas industries—Flexible couplings for mechanical power transmission—General-purpose applications*

ISO 15649:2001, *Petroleum and natural gas industries—Piping*

ISO 21049:2004, *Pumps—Shaft sealing systems for centrifugal and rotary pumps*

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[11] Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, New Jersey 08854, www.ieee.org.

MSS SP-44:2006 [12], *Steel Pipeline Flanges*

MSS SP-55:2006, *Quality Standard for Steel Castings for Valves, Flanges, Fittings and Other Piping Components—Visual Method for Evaluation of Surface Irregularities*

NACE MR 0103:2007 [13], *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

NACE MR 0175:2003, *Materials for Use in H_2S-containing Environments in Oil and Gas Production*

NACE *Corrosion Engineer's Reference Book*

NFPA 70 [14], *National Electrical Code*

SSPC SP 6:2000 [15], *Commercial Blast Cleaning*

2.2 All referenced standards, to the extent specified in the text, are normative.

2.3 Notes following a paragraph are informative.

2.4 The editions of standards, codes, and specifications that are in effect at the time of publication of this standard shall, to the extent specified herein, form a part of this standard. The applicability of changes in standards, codes, and specifications that occur after the inquiry shall be mutually agreed upon by the purchaser and the vendor.

3 Terms and Definitions

For the purposes of this standard, the following terms and definitions apply.

3.1
acoustical simulation
Process whereby the acoustical characteristics of fluids and the rotary pump dynamic flow influence are modeled.

3.2
alarm point
Preset value of a measured parameter at which an alarm is activated to warn of a condition that requires corrective action.

3.3
anchor bolt
Bolt used to attach the baseplate to the support structure (concrete foundation or steel structure).

3.4
baseplate
Component on which the drive train and pump are bolted, which is then fastened to the support structure using anchor bolts.

3.5
capacity
Flowrate.

[12] Manufacturers Standard Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180-4602, www.mss-hq.com.
[13] NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77218-8340, www.nace.org.
[14] National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.
[15] The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, Pennsylvania 15222, www.sspc.org.

3.6
certified material test report
CMTR
Certified report documenting the actual chemical composition and/or physical properties of critical materials.

3.7
datum elevation
Elevation to which values of NPSH are referred (concrete foundation or steel structure to which the baseplate is attached); also see paragraph defining NPSH (see 3.38).

3.8
depressurization valve
Valve, external to the MPP, used to relieve the gas pressure within the MPP package to a blow-down system or flare.

NOTE Also known as a blow-down valve.

3.9
design
Manufacturer's calculated parameter.

NOTE A term used by the equipment manufacturer to describe various parameters such as design power, design pressure, design temperature, or design speed. It is not intended for the purchaser to use this term.

3.10
differential pressure
Change in energy of the pumped liquid due to its pressure change in the pump. Typically, the discharge pressure minus the suction pressure.

3.11
discharge pressure
Energy of the pumped liquid due to its pressure as measured immediately downstream of the pump discharge flange.

3.12
displacement
Volume transferred from the suction to discharge per revolution of the rotor(s). In pumps incorporating two or more rotors operating at different speeds, the displacement is the volume transferred per revolution of the driving rotor. Displacement depends only on the physical dimensions of the pumping elements.

3.13
drive train components
Item of the equipment used in series to drive the pump (e.g. motor, gear, turbine, engine, fluid drive, clutch).

3.14
fail safe
System which will cause the equipment to revert to a permanently safe condition (shutdown and/or depressurized) in the event of a component failure or failure of the energy supply to the system.

3.15
flammable liquid
Liquid that has a closed-cup flash point below 38 °C (100 °F), as determined by recommended test procedures and apparatus.

NOTE Suitable test procedures are those set forth in NFPA 3.

3.16
gas liquid ratio
GLR
Ratio of the volume of gas to the volume of total liquid (oil and water only) at pump suction temperature and pressure.

3.17
gas oil ratio
GOR
Ratio of gas in a well stream expressed in standard cubic meters of gas per cubic meter of oil, Nm^3/m^3 in SI units or standard cubic feet of gas per barrel of oil, ft^3/bbl in USC units.

3.18
gas volume fraction
GVF
Ratio of volume of gas to that of the total volume of the fluid (oil, water, and gas) at pump suction temperature and pressure, the fraction being expressed as a percentage.

3.19
gauge board
Bracket or plate used to support and display gauges, switches, and other instruments.

NOTE A gauge board is open and not enclosed.

3.20
hold-down bolt
mounting bolt
Bolt holding the equipment to the baseplate.

3.21
hydrostatic test pressure
Static test pressure used for leak testing.

NOTE Depending upon pump type, areas or regions of the pump subject to suction pressure may be hydrotested at a lower pressure than regions subject to discharge pressure.

3.22
inspection and test plan
ITP
Single project-specific document used with extended scope for heavy duty pumps in complex packages to consolidate all inspection and test elements, the criteria required to be met, and the roles and responsibilities.

3.23
local
Position of devices mounted on or near the equipment or console.

3.24
maximum allowable casing pressure
MACP
Maximum pressure for which the manufacturer has designed the pressure-containment components at the specified operating temperature.

3.25
maximum allowable fluid temperature
Maximum continuous fluid temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure.

3.26
maximum allowable suction pressure
MASP
Maximum continuous allowable pressure of the suction regions of the pump.

NOTE MASP may be limited by the design of the suction region(s) of the pump, or, limited by the dynamic sealing pressure rating of mechanical seal(s).

3.27
maximum allowable working pressure
MAWP
Maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature.

3.28
maximum continuous allowable speed
Highest rotational speed (revolutions per minute) at which the machine, as-built and tested, is capable of continuous operation with the specified fluid at any of the specified operating conditions.

3.29
minimum allowable fluid temperature
Lowest fluid temperature for which the manufacturer has designed the equipment (or any part to which the term is referred).

3.30
minimum continuous allowable speed
Lowest rotational speed (revolutions per minute) at which the manufacturer's design will permit continuous operation with the specified fluid at any of the specified operating conditions.

3.31
minimum design metal temperature
Lowest mean metal temperature (through the thickness) expected in service, including operation upsets, auto-refrigeration and temperature of the surrounding environment.

3.32
multiphase fluid
Fluid comprised of two or more phases where one phase is a gas and one phase is a liquid and particulate may be present.

3.33
multiphase pump
MPP
Pump designed to successfully handle multiphase fluids.

3.34
net positive inlet pressure
NPIP
Minimum pressure determined at the datum elevation minus the vapor pressure of the fluid at the maximum operating temperature at any specified point.

3.35
net positive inlet pressure available
NPIPA
NPIP determined by the purchaser from the NPSHA and system design data.

3.36
net positive inlet pressure required
NPIPR
Minimum NPIP required by the pump to achieve the required performance with the specified fluid at any specified point, as determined by vendor.

3.37
net positive inlet pressure required test
NPIPR test
Test conducted to measure the NPIPR.

3.38
net positive suction head
NPSH
Total absolute suction head determined at the suction nozzle and referred to the datum elevation minus the head of the vapor pressure of the fluid.

NOTE It is expressed as head of water, in meters (feet).

3.39
net positive suction head available
NPSHA
Minimum value of NPSH determined to be available under any specified operating condition, accounting for line losses, under steady state flow conditions.

NOTE NPSHA is a value provided by the purchaser and which the purchaser shall use to calculate the NPIPA (see 3.35). NPSHA is a function only of the system upstream of the pump and the operating conditions, and is independent of pump design.

3.40
net positive suction head required
NPSHR
Minimum value of NPSH determined to be required under any specified operating condition, based on steady state flow.

NOTE NPSHR is a value provided by the vendor by taking the equipment requirements, which are based on the centerline of inlet reference point, and adjusting it to the underside of the baseplate. It correlates to the NPIPR (see 3.36).

3.41
nominal pipe size
NPS
Designation, usually followed by a size number designation number, corresponding approximately to the outside diameter of the pipe expressed in inches.

3.42
nominal pressure
PN
Numerical designation relating to pressure that is a convenient round number for reference purposes.

3.43
nondestructive examination
NDE
Inspection of materials, components or assemblies by means of radiography, liquid penetrant, magnetic particle or ultrasonic testing are the typical methods employed. Other methods may be used if agreed to by the purchaser and vendor.

3.44
normal capacity
Flowrate at which the pump is expected to operate under normal process conditions.

3.45
normal operating point
Point at which the pump is expected to operate under normal process conditions.

3.46
observed (test)
Inspection (test) for which the purchaser is notified of the timing, and the inspection (test) is performed as scheduled regardless of whether the purchaser or purchaser's representative is present.

NOTE Vendor will not hold up production for purchaser's convenience.

3.47
owner
Final recipient of the equipment who may delegate another agent as the purchaser of the equipment.

3.48
panel
Enclosure used to mount, display, and protect gauges, switches, and other instruments.

3.49
performance test
Running test conducted to measure flow rate, differential pressure, and power consumed at specified conditions.

NOTE Test results need to be corrected to service conditions, e.g. viscosity.

3.50
pocket passing frequency
Frequency at which the fluid is discharged from the screw leads (starts) into the pump discharge port.

NOTE Pocket passing frequency (Hz) is calculated by multiplying the rotor rotational speed (revolutions per minute) by the number of screw leads (starts) on that rotor and dividing the product by 60.

3.51
positive material identification
PMI
Physical evaluation or test of a material to confirm that the material is consistent with the selected or specified alloy material designated.

NOTE Adapted from API 578.

3.52
pressure-containing part
Any part that acts as a barrier between process or motive fluid and the atmosphere.

3.53
pressure-limiting valve accumulation pressure
PLV accumulation pressure
Pressure at which a PLV discharges the pump rated flow rate.

3.54
pressure-limiting valve set pressure
PLV set pressure
Pressure at which a PLV starts to release pressure by discharging flow.

3.55
pressure-retaining part
Any part whose mechanical failure would allow process or motive fluid to escape to the atmosphere.

3.56
pump efficiency
Ratio of the pump's hydraulic power at discharge to its brake power input.

NOTE The hydraulic power is calculated significantly different in compressible (multiphase) fluids (see specific paragraphs on MPPs).

3.57
purchaser
Agency that issues the order and specification to the vendor.

NOTE The purchaser may be the owner of the plant in which the equipment is to be installed or the owner's appointed agent.

3.58
Ra
Arithmetic average of the absolute value of the profile height deviations recorded within the evaluation length and measured from the mean line.

3.59
rated operating point
Point at which the vendor certifies that pump performance is within the tolerances stated in this standard.

NOTE Normally the rated operating point is the specified operating point with the highest flow.

3.60
rated power
Power delivered to the pump input shaft at rated operating point. It is also called brake power (brake horsepower, brake kilowatts, etc.).

3.61
rated pump efficiency
Pump efficiency at rated operating point (see pump efficiency).

3.62
rated speed
Highest rotational speed (revolutions per minute) required to meet any of the specified operating conditions.

NOTE Rated speed may not be the normal operating speed since the normal operating speed is determined by the normal operating point.

3.63
rated volumetric efficiency
Volumetric efficiency at rated operating point [see **volumetric efficiency** (3.77)].

3.64
remote
Control device located away from the equipment or console, typically in a control room.

3.65
rotary pump
Positive displacement pump consisting of a casing containing gears, screws, lobes, cams, or vanes actuated by relative rotation between the drive shaft and the casing. There are no separate inlet and outlet valves. These pumps are characterized by their close running clearances.

3.66
settle-out pressure
Highest pressure the MPP will experience when not running and after equilibrium has been reached.

NOTE This may be a function of ambient temperature, PLV setting, and piping volume.

3.67
shutdown set point
Preset value of a measured parameter at which automatic or manual shutdown of the system or equipment is required.

3.68
slip
Quantity of fluid per unit of time that leaks through the internal clearances of a rotary pump. Slip depends on the internal clearances, the differential pressure, the characteristics of the fluid handled, and in some cases, the speed.

3.69
special tool
Tool that is not a commercially available catalogue item.

3.70
steady state
Condition under which specific metering parameters such as: flow rate, differential pressure, speed, GVF, suction pressure, discharge pressure, and fluid type are not changing by more than ±10 % over a two-minute period.

3.71
suction pressure
The energy of the pumped liquid due to its pressure as measured upstream of the pump suction flange.

3.72
timing gear load
Forces and moments acting on the timing gear teeth and shafting during any portion of the pumping cycle.

3.73
total indicator reading
TIR, also known as total indicated run out
Difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface for one complete revolution.

NOTE For a cylindrical surface, the indicated run-out implies an eccentricity equal to half the reading. For a flat face, the indicated run-out implies an out-of-squareness equal to the reading. If the diameter in question is not cylindrical or flat, the interpretation of the meaning of TIR is more complex and may represent ovality or surface irregularities.

3.74
trip speed
Speed (revolutions per minute) at which the independent emergency overspeed device operates to shut down a variable speed prime mover. The trip speed of any alternating current electric motors, except variable frequency drives, shall be considered to be the speed corresponding to the synchronous speed of the motor at maximum supply frequency.

3.75
unit responsibility
Responsibility for coordinating the technical aspects, delivery, and documentation of the equipment and all auxiliary systems included in the scope of the order.

3.76
vendor
supplier
Manufacturer or manufacturer's agent that supplies the equipment and is normally responsible for service support.

3.77
volumetric efficiency
Ratio of the pump rated point flow to the total theoretical displacement per unit time.

NOTE Volumetric efficiency is normally expressed as a percentage.

3.78
witnessed (test)
Inspection or test where the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or the purchasers representative is in attendance.

4 General

4.1 Unit Responsibility

Unless otherwise specified, the pumpvendor shall have unit responsibility. The pump vendor who has unit responsibility shall ensure that all sub-vendors comply with the requirements of this standard and all reference documents. These include, as a minimum, such factors as the functionality, power requirements, speed, rotation, general arrangement, couplings, dynamics, noise, lubrication, sealing system, material test reports, instrumentation, piping, documentation, conformance to specifications, and testing of components by vendor and any and all subvendors.

4.2 Governing Requirements and Units of Measurement

4.2.1 In case of conflict between this standard and the inquiry, the inquiry shall govern. At the time of the order, the order shall govern.

4.2.2 Drawings and maintenance dimensions of pumps shall be in SI units or US Customary (USC) units. Use of an ISO standards datasheet indicates SI units shall be used. Use of a USC datasheet indicates USC units shall be used.

4.2.3 Whether the application is a liquid or a multiphase service, if MPP design criteria are required by the service conditions or specified by the purchaser by use of the multiphase datasheets, all of the standard clauses will apply, except where noted or qualified otherwise in this standard.

NOTE The following listing identifies the paragraphs where unique MPP design and testing requirements are described—3.8, 3.16, 3.17, 3.18, 3.32, 3.33, 3.50, 3.66, 3.70, 6.7.2.2, 6.8.1.3, 6.8.1.8, 6.8.2.2, 6.10.1, 6.11.2, 7.1.1.1, 7.3.5, 7.6.1, 7.8, 8.1.8, 8.3.8, 9.2.4, Annex F, and Annex G.

4.3 Pump Designations

4.3.1 General

NOTE Pictures and modified descriptions are used with permission of the Hydraulic Institute.

The pumps described in this standard are classified and designated as shown in Table 1.

Table 1—Pump Classification Type Identification

Pump Type (by Pumping Element)		Type	Type Code
rotary pumps	vane	vane in rotor	VR
		vane in stator	VS
	lobe	single	LS
		multiple	LM
	gear	external gears (timed)	GET
		external gears (untimed)	GEU
		internal gears (with crescent)	GI
	screw	single	SS
		multiple timed	SMT
		multiple untimed	SMU

NOTE Typical flows and pressures for these types of pumps are shown in Figure 9 and Figure 10, which have been provided courtesy of the Hydraulic Institute.

4.3.2 Sliding Vane Pump

In vane pumps, the vane or vanes are moved by a rotor, thereby drawing fluid into and forcing it from the pump chamber. These pumps may be made with vanes in either the rotor or stator and with radial hydraulic forces on the rotor balanced or unbalanced.

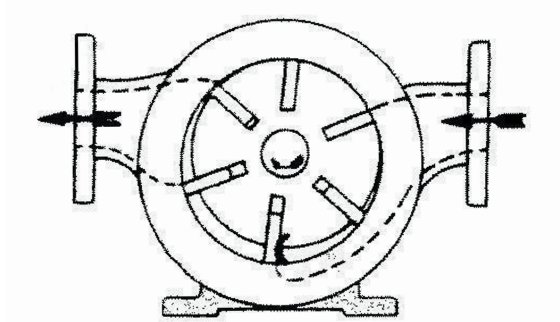

Figure 1—Sliding Vane Pump (Vane in Rotor)

4.3.3 Lobe Pump

In lobe pumps, fluid is carried between rotor lobe surfaces and the pumping chamber from the inlet to the outlet. The rotor surfaces cooperate to provide continuous sealing. The rotors must be timed by separate means. Each rotor has one or more lobes.

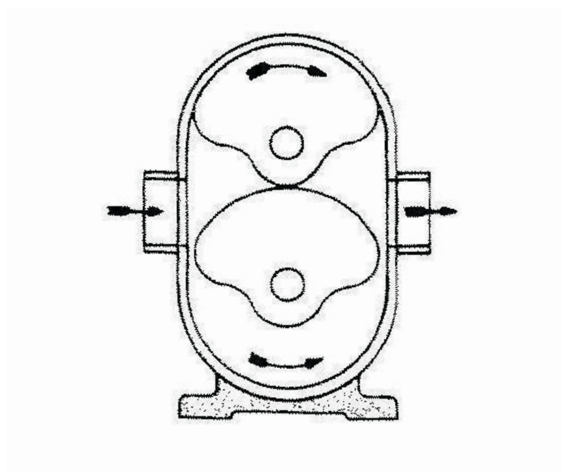

Figure 2—Single Lobe Pump

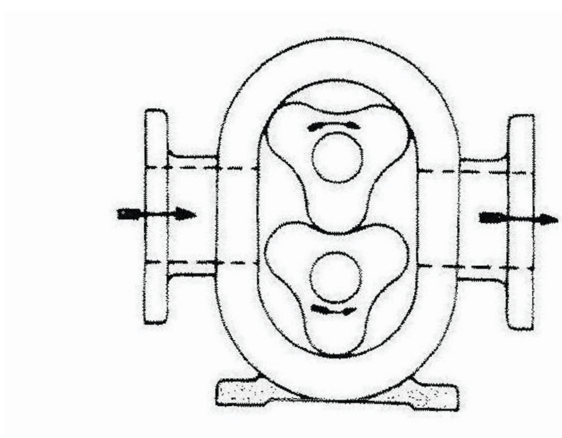

Figure 3—Three Lobe Pump

4.3.4 External Gear Pump

In gear pumps, fluid is carried between gear teeth and displaced when they mesh. The surfaces of the rotors cooperate to provide continuous sealing and either rotor is capable of driving the other. External gear pumps have all gear rotors cut externally. These may have spur, helical, or herringbone (double helical) gear teeth and may use timing gears.

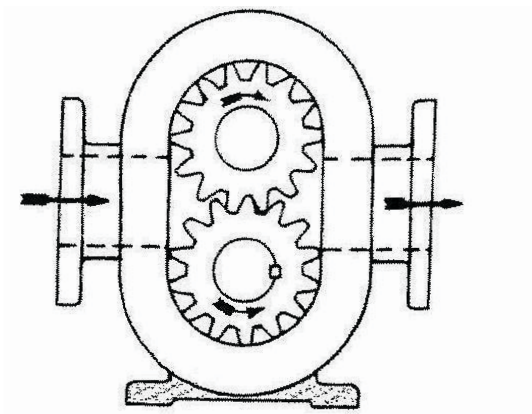

Figure 4—External Gear Pump

4.3.5 Internal Gear Pump (with Crescent)

Internal gear pumps have one rotor with internally cut gear teeth meshing with an externally cut gear. Pumps of this type are made with a crescent-shaped partition.

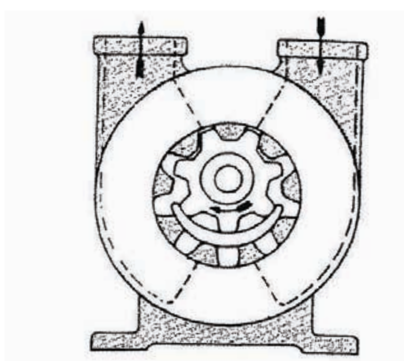

Figure 5—Internal Gear Pump

4.3.6 Progressing/Progressive Cavity Pump (PCP)

In screw pumps, fluid is carried in spaces formed by screw(s) and the screw housing and is displaced axially as they mesh.

Single screw pumps (progressing cavity pumps), illustrated in Figure 6, have a rotor with external threads and a stator with internal threads. The rotor threads are eccentric to the axis of rotation.

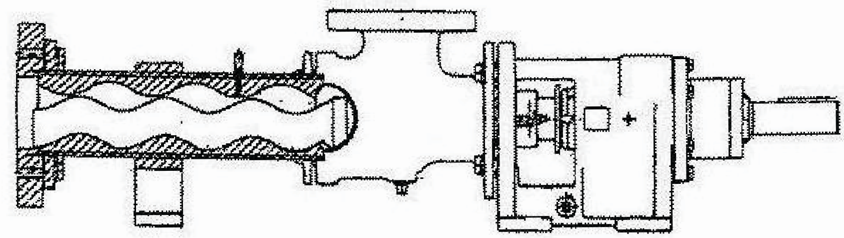

Figure 6—Progressing/Progressive Cavity Pump (PCP)

4.3.7 Multiple Screw Pump

Multiple screw pumps have multiple external screw threads. Such pumps as those illustrated in Figure 7 and Figure 8 may be timed or untimed.

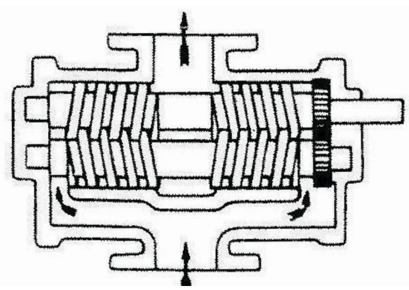

Figure 7—Twin Screw Pump (with Timed Gears)

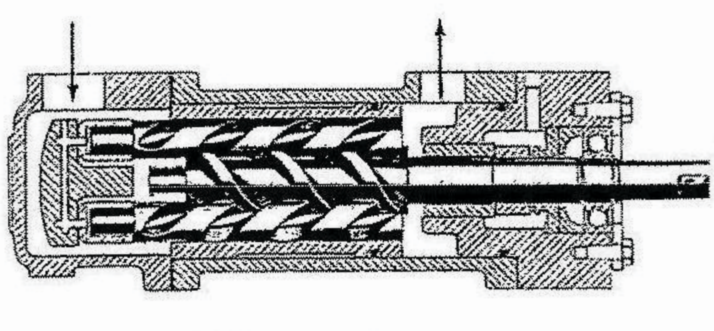

Figure 8—Three-screw Pump (with Untimed Gears)

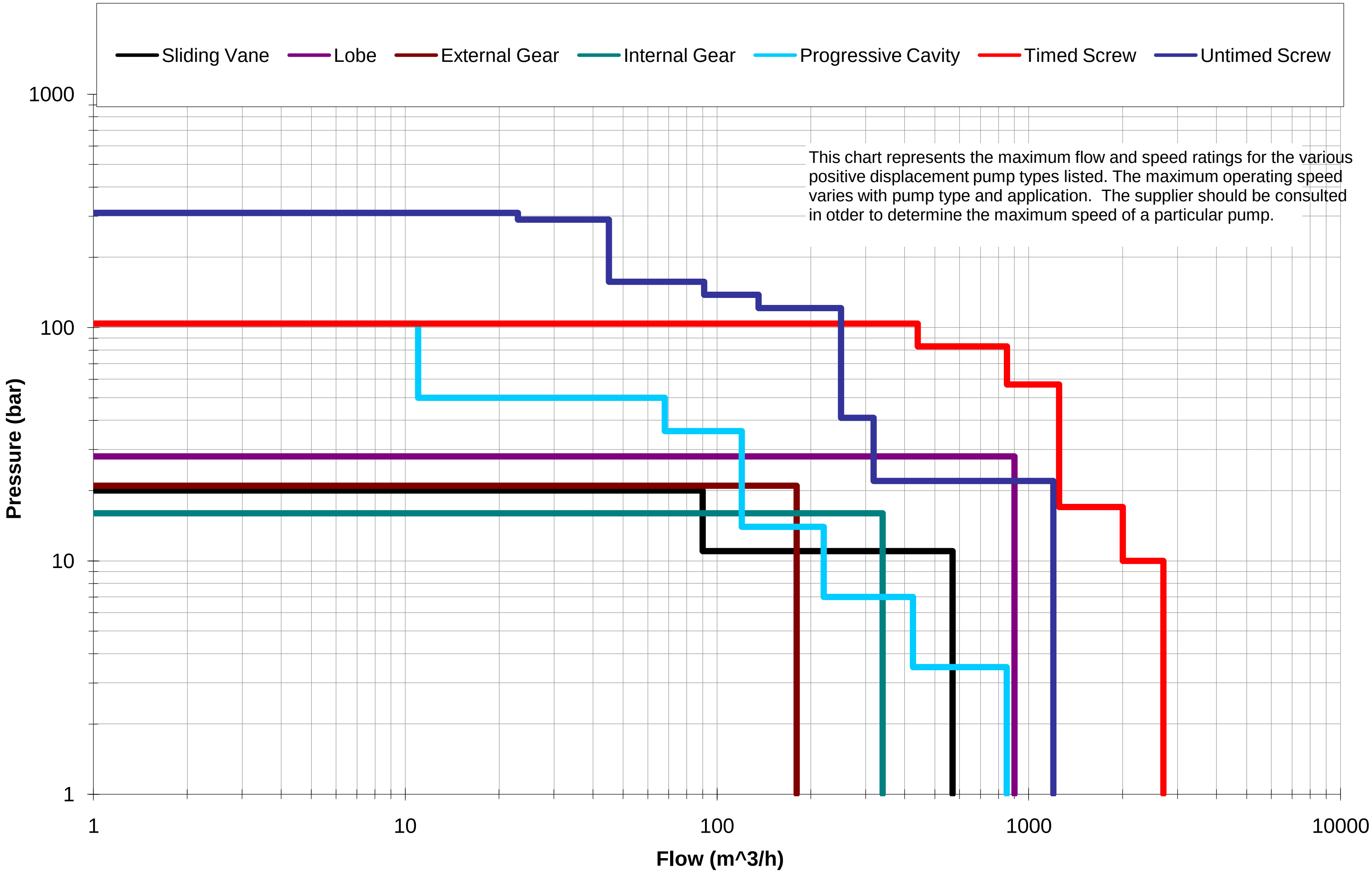

Figure 9—Rotary Pump Consolidated Range Chart (SI Units)

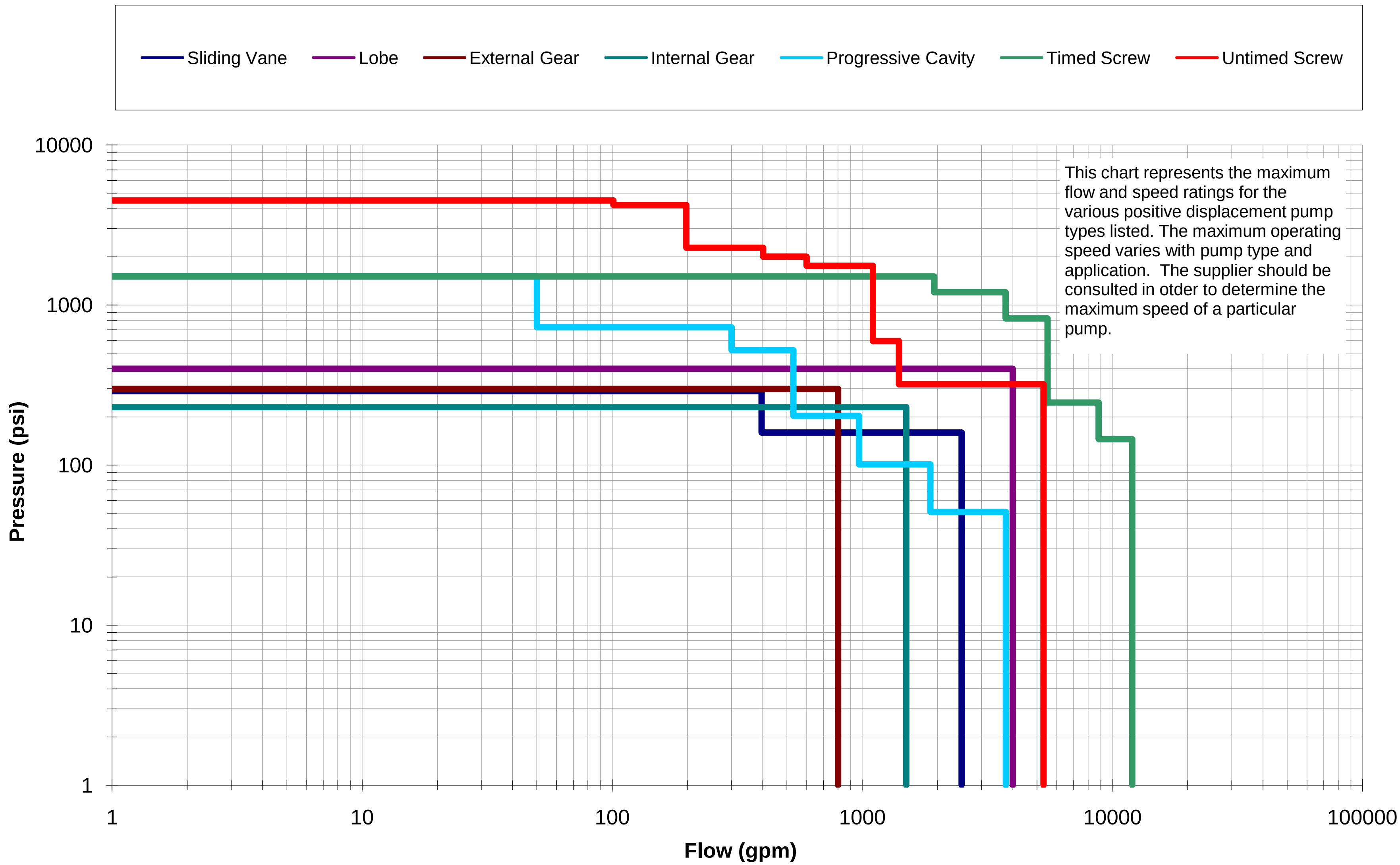

Figure 10—Rotary Pump Consolidated Range Chart (USC Units)

5 Statutory

5.1 Statutory Requirements

The purchaser and the vendor shall mutually determine the measures to be taken to comply with any governmental codes, regulations, ordinances, or rules that are applicable to the equipment, its packaging and any preservatives used (ISO Directives Part 3:1997, Annex E).

5.2 Requirements

5.2.1 In case of conflict between this standard and the inquiry, the inquiry shall govern. At the time of the order, the order shall govern.

5.2.2 If requirements specific to a particular pump type in Section 6 conflict with any other clauses, the requirements of Section 6 shall govern.

6 Basic Design

6.1 General

6.1.1 The equipment including auxiliaries, but excluding normal maintenance, shall be designed and constructed for a minimum service life of 20 years and at least three years of uninterrupted operation. It is recognized that these requirements are design criteria, and that service or duty severity, misoperation or improper maintenance can result in a machine failing to meet these criteria.

The term “design” shall apply to parameters or features of the equipment supplied by the manufacturer. The term “design” should not be used in the purchaser’s enquiry or specification because it can cause confusion in understanding the order.

● **6.1.2** The purchaser shall specify the normal operating point, rated operating point, and all other required operating points. If a range of operating conditions is specified, the pump vendor shall advise the purchaser about the pump’s minimum and maximum capacity at its rated differential pressure and its required brake horsepower. Anticipated process variations that may affect the sizing of the pump and the driver (such as changes in pressure, temperature, or properties of fluids handled, and special plant startup conditions) shall be specified.

● **6.1.3** Pumps shall be designed for flammable or hazardous services. If specified that the pump is to be used in nonflammable or nonhazardous services, the vendor may provide an alternate design.

6.1.4 Control of the sound pressure level of all equipment supplied shall be a joint effort of the purchaser and the vendor having unit responsibility. The equipment provided by the vendor shall conform to the maximum allowable sound pressure level specified. In order to determine compliance, the vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment.

6.1.5 Equipment shall be selected to run simultaneously at the pressure-limiting accumulation pressure and at trip speed without suffering damage. Vendor shall advise purchaser of increased power operating requirements necessary to achieve this.

6.1.6 For direct-driven equipment, the equipment’s maximum continuous allowable speed shall be not less than 105 % of the rated speed for adjustable speed machines and shall be equal to the rated speed for constant speed motor drives.

6.1.7 For gear-driven equipment, the gearbox input shaft maximum continuous allowable speed shall not be less than 105 % of the rated speed for adjustable speed machines and shall be equal to the rated speed for constant speed motor drives.

6.1.8 The equipment's trip speed shall not be less than the following percentages of maximum continuous allowable speed:

a) adjustable speed motor—110 %,

b) constant speed motor—100 %,

c) reciprocating engine—110 %.

6.1.9 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the purchaser and the vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.

● **6.1.10** Motors, electrical components, and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser and shall meet the requirements of the applicable sections of IEC 60079, or NFPA 70, API 500, and NEC as specified, as well as any local codes specified and supplied by the purchaser.

6.1.11 Oil reservoirs and housings that enclose moving lubricated parts such as bearings, shaft seals, highly polished parts, instruments, and control elements shall be designed to minimize contamination by moisture, dust, and other foreign matter during periods of operation and idleness.

6.1.12 All equipment shall be designed to permit rapid and economical maintenance, particularly regarding packing and seals. Major parts shall such as casing components and bearing housings shall be designed and manufactured to ensure accurate alignment on reassembly. This may be accomplished by the use of shouldering, cylindrical dowels, or keys.

6.1.13 All equipment (machine, driver, and auxiliary equipment as specified) shall be designed to perform on the test stand and on its permanent foundation within the specified test tolerances (see 6.11 and 8.3.6). After installation, the performance of the combined units shall be the joint responsibility of the purchaser and the vendor who has unit responsibility.

NOTE Many factors can adversely affect performance of the pump at site. These factors include piping layout, piping connection loads, alignment at operating conditions, support structure, handling during shipment and handling and assembly on site.

● **6.1.13.1** If specified, for MPPs, the vendor shall confirm that the unit is capable of start-up at settle-out and maximum suction pressure.

● **6.1.14** The equipment, including all auxiliaries, shall be suitable for operation under the environmental conditions specified by the purchaser. The environmental conditions shall include whether the installation is indoors (heated or unheated) or outdoors (with or without a roof), maximum and minimum temperatures, unusual humidity, dusty, or corrosive conditions.

6.1.15 The equipment, including all auxiliaries shall be suitable for operation using the utility conditions specified.

6.1.16 Spare and replacement parts for the machine and all furnished auxiliaries shall meet all the criteria of this standard.

6.1.17 Bolting

6.1.17.1 Bolting shall conform to 6.1.17.2 through 6.1.17.5.

6.1.17.2 Details of threading shall conform to ISO 261, ISO 262, ISO 724, and ISO 965 or to ASME B1.1.

6.1.17.3 Internal-socket-type, slotted-nut or spanner-type bolting shall not be used.

NOTE There may be certain unusual designs that may require this configuration. Application requires specific purchaser approval.

6.1.17.4 Fasteners (excluding washers and set-screws) shall have the material grade and manufacturer's identification symbols applied to one end of studs 10 mm (0.38 in.) in diameter and larger and to the heads of bolts 6 mm (0.25 in.) in diameter and larger. If the available area is inadequate, the grade symbol may be marked on one end and the manufacturer's identification symbol marked on the other end. Studs shall be marked on the exposed end.

NOTE A set-screw is a headless screw with an internal hexagonal opening in one end.

6.1.17.5 Metric fine and UNF threads shall not be used.

6.1.18 Pump Mounting Surfaces

6.1.18.1 The pump mounting surfaces shall meet the following criteria.

6.1.18.2 They shall be fully machined to a finish of 6.3 μm (250 μin.) arithmetic average roughness (Ra) or smoother.

6.1.18.3 To prevent a soft foot, each individual mounting surface will be machined with a flatness tolerance of 25 μm (0.001 in.).

6.1.18.4 The mounting surfaces shall be machined flat and parallel. Corresponding surfaces shall be in the same plane within 150 μm/m (0.002 in./ft) of distance between the mounting surfaces.

6.1.18.5 The upper machined, or spot faced surface, shall be parallel to the mounting surface.

6.1.18.6 Hold-down bolt holes shall be drilled perpendicular to the mounting surface or surfaces, machined or spot faced to a diameter three times that of the hole and to allow for equipment alignment. For hold-down bolts 25 mm (1 in.) and larger the hole shall be 13 mm (0.50 in.) larger in diameter than the hold-down bolt. For bolts less than 25 mm (1 in.) in diameter, the holes shall be 5 mm (0.25 in.) larger in diameter than the bolt.

6.2 Selection and Rating of Pump Type

6.2.1 Unless otherwise specified, the vendor shall recommend the pump speed for the specified service, considering such factors as net positive suction head available (NPSHA), net positive suction head required (NPSHR), maximum fluid viscosity, solids and abrasives content, and wear allowance if required.

NOTE It must be recognized that different rotary pump designs operate on different principles so that no one speed criterion can be applied.

6.3 Pressure-containing and Pressure-retaining Parts

6.3.1 The pressure-containing parts shall be designed in accordance with 6.3.1.1 (or 6.3.1.2, as selected by the vendor) and 6.3.1.3 to achieve the following:

a) operate without leakage while subject simultaneously to the maximum allowable casing pressure (MACP) (and corresponding temperature) and the worst case combination of maximum allowable nozzle loads applied to all nozzles,

b) withstand the hydrostatic test in 8.3.2.

6.3.1.1 Pressure-containing components may be designed with the aid of finite element analysis provided that the value of the stress intensity reflects a requirement to perform a hydrotest at 150 % of MACP.

6.3.1.2 The allowable tensile stress used in the design of the pressure components, excluding bolting, for any material shall not exceed 0.25 times the minimum ultimate tensile strength or 0.67 times the minimum yield strength for the material whichever is lower across the full range of specified operating temperature.

6.3.1.3 For casing joint bolting, the allowable stress, as determined in 6.3.1.2 shall be used to determine the total bolting area based on hydrostatic load and gasket preload, as applicable. The preload stress shall not exceed 0.75 times the bolting material minimum yield strength.

NOTE Preloading the bolting is required to prevent unloading the bolted joint due to cyclic operation.

6.3.1.4 A corrosion allowance of at least 3 mm (0.12 in.) shall be added to the casing thickness used in 6.3.1. The corrosion allowance shall also be added to all auxiliary connections exposed to the same fluid as the pressure-containing casing.

NOTE The vendor may propose alternative corrosion allowances for consideration if materials of construction with superior corrosion resistance are employed.

6.3.2 The purchaser shall install a pressure-limiting valve (PLV) for each positive displacement pump. The PLV accumulation pressure shall not exceed the maximum allowable working pressure (MAWP) of the pump.

6.3.3 Casing and other pressure-retaining parts and supports shall be designed to prevent detrimental distortion caused by the worst combination of temperature, pressure, torque, and allowable external forces and moments based on the specified operating conditions.

6.3.3.1 Unless otherwise specified, the suction region and the discharge region of the pump shall be designed for different pressure ratings.

● **6.3.3.2** If specified, suction regions shall be designed for the same MACP as the discharge section.

6.3.3.3 Casings shall be sealed using flat gaskets; confined, controlled-compression spiral wound gaskets, or O-rings.

6.3.4 The use of threaded holes in pressure-retaining parts shall be minimized. To prevent leakage in these parts, metal equal in thickness to at least half the nominal bolt diameter (including the allowance for corrosion) shall be left around and below the bottom of drilled and threaded holes. The depth of the threaded holes shall be at least 1.5 times the stud diameter.

6.3.5 If required by the pump design, jackscrews, cylindrical alignment dowels and/or other appropriate devices shall be provided to facilitate disassembly. If jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counter-bored or recessed) to prevent a leaking joint or an improper fit caused by marring of the face.

6.3.6 If jacketed pump casings are required, they shall be designed to positively prevent process fluid from leaking into the jacket.

6.3.7 Unless otherwise specified, jackets shall be designed for minimum of 5.2 bar gauge (75 psig) working pressure and shall be suitable for hydrostatic testing at a minimum of 8 bar gauge (115 psig).

6.4 Casing Connections

6.4.1 Provision shall be made for complete venting (unless it is self-venting) and draining of the pump and systems provided by the vendor.

6.4.2 All pumps shall be provided with vent and drain connections, except that vent connections may be omitted if the pump is made self-venting by the arrangement of the nozzles.

6.4.2.1 If the pump cannot be completely drained for geometrical reasons, this shall be stated in the proposal.

6.4.2.2 The operating manual shall include a drawing indicating the quantity and location(s) of the fluid remaining in the pump.

NOTE A pump is considered functionally self-venting if the nozzle arrangement and the casing configuration permit sufficient venting of gases to prevent loss of prime during the starting sequence.

6.4.3 Casing Opening Sizes

6.4.3.1 Openings for nozzles and other pressure casing connections shall be standard pipe sizes in accordance with ISO 6708 or ASME B16.5. Openings of DN 32, 65, 90, 125, 175, and 225 (NPS 1 $^1/_4$, 2 $^1/_2$, 3 $^1/_2$, 5, 7, and 9) shall not be used.

6.4.3.2 Casing connections other than suction and discharge nozzles shall be at least DN 15 (NPS $^1/_2$) for pumps with discharge nozzle openings DN 50 (NPS 2) and smaller. Connections shall be at least DN 20 (NPS $^3/_4$) for pumps with discharge nozzle openings DN 80 (NPS 3) and larger, except that connections for seal flush piping and gauges may be DN 15 (NPS $^1/_2$) regardless of pump size.

6.4.4 Suction and Discharge Nozzles

6.4.4.1 Suction and discharge nozzles shall be flanged or machined and studded for sizes DN 50 (NPS 2) and larger. Sizes DN 40 (NPS 1 $^1/_2$) and smaller may be threaded connections.

NOTE When machined and studded suction and discharge nozzles are provided, purchaser shall supply and install piping spool pieces near the pump, so that large sections of piping do not have to be disassembled in order to remove the pump for a major overhaul.

● **6.4.4.2** If specified, all connections shall be suitable for the MACP.

6.5 Auxiliary Connections

6.5.1 Connections welded to the casing shall meet the material requirements of the casing including impact values, rather than the requirements of the connected piping. All welding of connections, gussets, etc. shall be completed before the casing is hydrostatically tested (see 8.3.2).

● **6.5.2** If specified, piping shall be gusseted in two orthogonal planes to increase the rigidity of the piped connection.

6.5.2.1 Gussets shall be of a material compatible with the pressure casing and the piping and shall be made of flat bar with a minimum cross section of 25 mm × 3 mm (1 in. × 0.12 in.).

6.5.2.2 Gussets shall be located at or near the connection end of the piping, and fitted to the closest convenient location on the casing to provide maximum rigidity. The long width of the bar shall be perpendicular to the pipe and shall be located to avoid interference with the flange bolting or any maintenance areas on the pump.

6.5.2.3 Gusset welding must meet the fabrication requirements of 6.13.5, including postweld heat treatment when required, and the inspection requirements of this standard (see 8.2.2).

6.5.2.4 Gussets may also be bolted to the casing if drilling and tapping is done prior to the hydrotest.

6.5.2.5 Piping may be clamped to gussets.

6.5.3 If recommended by the vendor and approved by the purchaser, threaded connections for pipe sizes exceeding DN 40 (1 $^1/_2$ NPS) may be used.

NOTE For example:

a) on nonweldable materials, such as cast iron;

b) if essential for maintenance (disassembly and assembly); and

c) where flanged or machined and studded openings are impractical.

6.5.3.1 Unless otherwise recommended by the vendor and approved by the purchaser, pipe nipples screwed or welded to the casing should not be more than 150 mm (6 in.) long and shall be a minimum of Schedule 160 seamless for sizes DN 25 (NPS 1) and smaller and a minimum of Schedule 80 for DN 40 (NPS 1 $^1/_2$).

6.5.3.2 If recommended and approved, nipples longer than 150 mm (6 in.) shall be gusseted.

6.5.3.3 The pipe nipple shall be provided with a welding-neck or socket-weld flange.

6.5.3.4 All auxiliary connections to the pressure casing, except seal gland, shall terminate in a flange meeting the requirements of 6.6.1.1 or 6.6.1.2. These connections shall be integrally flanged, socket welded or butt welded as specified by the purchaser. Seal welding of threaded connections is not permitted. Purchaser interface connections shall terminate in a flange.

● **6.5.3.5** If specified, special threaded fittings for transitioning from the casing to tubing for seal flush piping may be used provided a secondary sealing feature such as O-rings are used and the joint does not depend on thread contact alone to seal fluid. The connection boss shall have a machined face suitable for sealing contact.

6.5.3.6 The nipple and flange materials shall meet the requirements of API 614/ISO 10438.

6.5.3.7 Unless otherwise specified, pipe threads shall be tapered threads conforming to ASME B1.20.1. Openings and bosses for pipe threads shall conform to ASME B16.5.

NOTE For purposes of this provision, ASME B1.20.1 is equivalent to ISO 7-1.

● **6.5.4** If specified, cylindrical threads conforming to ISO 228-1 shall be used. If cylindrical threads are used, they shall be sealed with a contained face gasket, and the connection boss shall have a machined face suitable for gasket containment.

● **6.5.4.1** If specified, auxiliary connections to the pressure casing shall be machined and studded. These connections shall conform to the facing and drilling requirements of ASME B16.5 or ASME B16.1. Studs and nuts shall be furnished installed. The first 1 $^{1}/_{2}$ threads at both ends of each stud shall be removed.

NOTE For the purpose of this provision, ASME B16.1 and ASME B16.5 are equivalent to ISO 7005-2 and ISO 7005-1, respectively.

6.5.4.2 All connections shall be suitable for the hydrostatic test pressure of the region of the casing to which they are attached.

6.5.4.3 Threaded openings not connected to piping shall be plugged. Taper-threaded plugs shall be long-shank solid round-head, or long-shank hexagon-head bar stock plugs in accordance with ASME B16.11. If cylindrical threads are specified, plugs shall be solid hexagon-head plugs in accordance with DIN 910. These plugs shall meet the material requirements of the casing. A lubricant that is suitable for the contained fluid and for the service temperature shall be used on all threaded connections. Thread tape shall not be used. Plastic plugs shall not be used.

6.6 Flanges

● **6.6.1** Purchaser to specify whether ISO or ASME flanges are to be provided.

6.6.1.1 Cast iron flanges shall be flat-faced and, except as noted in 6.6.1.3, conform to the dimensional requirements of ISO 7005-2 and the flange finish requirements of ASME B16.1 or ASME B16.42. Nominal pressure (PN) 20 (Class 125) flanges shall have a minimum thickness equal to that of PN 40 (Class 250) flanges for sizes DN 200 (NPS 8) and smaller.

NOTE ISO 7005-2 (cast iron) flanges PN 20 and PN 50 are designed to be interchangeable with ASME B16.1 (gray cast iron) and B16.42 (ductile cast iron) but they are not identical. They are deemed to comply with dimensions specified in ASME B16.1 (gray cast iron) and B16.42 (ductile cast iron).

6.6.1.2 Flanges other than cast iron shall, as a minimum requirement, conform to the dimensional requirements of ISO 7005-1 PN 50 except as noted in 6.6.1.3 and the flange finish requirements of ASME B16.5 or ASME B16.47.

NOTE 1 For the purpose of this provision, ASME B16.5 Class 300, ASME B16.47 Class 300, and EN 1759-1 Class 300 are equivalent to ISO 7005-1 PN 50.

NOTE 2 ISO 7005-1 (steel flanges) PN 20, PN 50, PN110, PN150, PN260, and PN420 are designed to be interchangeable with ASME B16.5 and MSS SP-44 flanges—ISO 7005-1 flanges are not identical to ASME B16.5 and MSS SP-44 flanges but are deemed to comply with the dimensions specified in the ASME B16.5 and MSS SP-44.

6.6.1.3 Flanges in all materials that are thicker or have a larger outside diameter than required by the relevant ISO (ASME) standards in this standard are acceptable. Nonstandard (oversized) flanges shall be identified as such and completely dimensioned on the arrangement drawing. If oversized flanges require studs or bolts of non-standard length, this requirement shall be identified as such on the arrangement drawing.

6.6.1.4 Flanges shall be full-faced or spot-faced on the back and shall be designed for through-bolting, except for jacketed casings.

6.6.1.5 Unless otherwise specified, the vendor shall provide mating flanges, studs and nuts for non-standard connections.

6.6.1.6 Studs or bolt holes shall straddle center lines parallel to the main axes of the equipment.

6.6.1.7 All of the purchaser’s connections shall be accessible for disassembly without requiring the machine, or any major part of the machine, to be moved.

6.7 External Forces and Moments

6.7.1 The vendor shall specify, in the quotation, the magnitude of forces and moments which may be applied, simultaneously, to the inlet and outlet connections at the rated operating conditions. As a minimum, the pump inlet and outlet connections must be capable of withstanding the limits indicated in Table 2.

Table 2—Nozzle Loadings

SI Units **Nominal Size of Flange** (DN)	**Forces Each Nozzle** F_x, F_y and F_z (N)	**Moments Each Nozzle** M_x, M_y and M_z (N·m)
≤50	650	350
80	1040	560
100	1300	700
150	1950	1050
200	2600	1400
250	3250	1750
300	3900	2100
350	4550	2450
400	5200	2800
500	6500	3500
600	7800	4200

USC Units **Nominal Size of Flange** (NPS)	**Forces Each nozzle** F_x, F_y and F_z (lbf)	**Moments Each Nozzle** M_x, M_y and M_z (ft-lbf)
≤2	150	250
3	225	375
4	300	500
6	450	750
8	600	1000
10	750	1250
12	900	1500
14	1050	1750
16	1200	2000
20	1500	2500
24	1800	3000

For pumps with connection sizes not indicated in Table 2, the inlet and outlet nozzles shall be capable of withstanding forces and moments from external piping determined by the following formulas:

$F_x = 13D \qquad M_x = 7D$

$F_y = 13D \qquad M_y = 7D$

$F_z = 13D \qquad M_z = 7D$

Or in conventional units:

$F_x = 75D \quad M_x = 125D$

$F_y = 75D \quad M_y = 125D$

$F_z = 75D \quad M_z = 125D$

where

D is the nominal pipe size (NPS) of the pump nozzle connection in millimeters (inches);

F_x is the force in Newtons (pounds) on the x-axis, which is parallel to the shaft axis;

F_y is the horizontal force in Newtons (pounds) on the y-axis, which is mutually perpendicular to the x- and z-axis;

F_z is the vertical force in Newtons (pounds) on the z-axis, which is mutually perpendicular to the y- and x-axes;

M_x is moment around the x-axis, in Newton-meters (pound-feet);

M_y is moment around the y-axis, in Newton-meters (pound-feet);

M_z is moment around the z-axis, in Newton-meters (pound-feet).

The vendor shall submit comparable criteria for pump casings constructed of other materials.

6.7.2 Casing Liners

● **6.7.2.1** If specified, replaceable liners shall be provided for screw pumps.

6.7.2.2 Unless otherwise specified for multiphase twin screw pumps, hard coatings and/or surface hardening shall be applied to the liner bores.

NOTE Hard-coated and/or surface-hardened liners are used to reduce the rate of degradation due to abrasives. See Annex B for additional information.

6.8 Rotating Elements

6.8.1 Rotors

6.8.1.1 Stationary and moving pumping elements shall be designed and fabricated of material to prevent galling. Rotating parts shall be properly aligned. Internal loads shall be fully supported by the use of such means as hydraulic balance, bearings, or bushings.

● **6.8.1.2** If specified, for twin screw pumps, rotor stiffness shall be adequate to prevent contact between the rotor bodies and the casing and between gear-timed rotor bodies at the most unfavorable specified conditions.

6.8.1.3 For twin screw MPPs, the maximum allowable rotor deflection under the worst operating condition (consider temperature, MAWP, nozzle loads, particulate, etc. as specified on the datasheet) shall be calculated and able to be demonstrated through computer modeling to show noncontact between rotors and the surrounding pump casing.

NOTE 1 If requested, the purchaser shall be able to review these calculations.

NOTE 2 This requirement does not apply to PCPs, since continuous contact/interference is required by design between the rotor and stator to seal off the pumping cavities.

6.8.1.4 Rotor bodies not integral with the shaft shall be positively attached to the shaft to prevent relative motion under any condition. Structural welds on rotors shall be full-penetration continuous welds and shall be stress relieved with appropriate ASTM heat treatment procedure.

6.8.1.5 For multiple screw pumps, each rotor set shall be clearly marked with a unique identification number on each male and female rotor. This number shall be on the end of the shaft opposite the coupling or in an accessible area that is not prone to maintenance damage.

6.8.1.6 All shaft keyways shall have fillet radii conforming to ASME B17.1.

● **6.8.1.7** If specified, hardened rotors shall be provided for screw pumps.

6.8.1.8 Unless otherwise specified for multiphase twin screw pumps, hard coatings and/or surface hardening shall be applied to the rotors.

NOTE Hard-coated and/or surface-hardened screws are used to reduce the rate of degradation due to abrasives (see Annex B for additional information).

6.8.1.9 Rotors for twin screw pumps shall be dynamically balanced to ISO 1940-1 Grade G2.5.

6.8.2 Timing Gears

6.8.2.1 Timing gears, when furnished, may be spur, helical, or herringbone (double helical) type. All gears shall be the coarse-pitch type, and the gear quality shall be at least nine as defined by AGMA. The gears shall be designed in accordance with AGMA 6010 with a minimum service factor of 1.5.

6.8.2.2 For twin screw MPPs, the timing gears shall be designed in accordance with AGMA 6010 with a minimum service factor of 2.0. The timing gears shall be made of forged steel and shall be manufactured to a minimum gear quality level of 11 as defined by AGMA.

● **6.8.2.3** If specified, the gear enclosing chamber shall not be subject to contact with the process fluid.

6.8.2.4 For external timing gears, inspection ports or other means shall be provided on the housing covers, such that timing gears may be inspected without disassembly of the unit.

6.9 Mechanical Shaft Seals

6.9.1 Unless otherwise specified, cartridge mechanical shaft seals shall be furnished.

6.9.2 Seal selection shall be suitable for specified variations in suction and/or discharge conditions during start-up, operation, or shutdown, including possible upset conditions.

NOTE If the seal is exposed to suction pressure, special consideration may also be necessary for low suction pressure conditions or when a pump is subjected to a NPSH test requirement.

6.9.3 Unless otherwise specified, shaft seals shall be provided in accordance with API 682/ISO 21049.

● **6.9.4** If specified, manufacturer’s standard seal meeting the intent of API 682/ISO 21049 shall be supplied. The following items shall be provided in the proposal:

a) category,

b) type,

c) arrangement and geometry,

d) materials of construction,

e) reference list.

NOTE Space or design parameters for some pump types, sizes, or applications make the use of API 682/ISO 21049 seals impractical.

6.9.5 This standard does not cover the design of the component parts of mechanical seals. However, the design of the component parts shall be suitable for the specified service conditions and consistent with API 682/ISO 21049. The purchaser shall specify the seal requirements using the selection process and the datasheets in API 682/ISO 21049 for this purpose including any required seal flush plans as defined by API 682/ISO 21049.

6.9.6 Single seals must be equipped with a close-fitting throttle bushing on the atmospheric side of the seal to restrict the rate of leakage. If this is not possible due to space limitations, a suitable means of detecting and controlling the leakage shall be provided.

6.9.7 The seal shall be accessible for inspection and removal without disturbing the driver. Unless otherwise specified, a spacer coupling, with a spacer of the next standard length longer than the seal shall be provided by the vendor.

6.9.8 Seal chamber face run-out (TIR) shall not exceed 0.5 μm/mm (0.0005 in./in.) of seal chamber bore diameter.

6.9.9 If a seal gland is used, its component parts shall be satisfactory for the maximum seal-chamber design pressure and pumping temperature. It shall have sufficient rigidity to avoid any distortion that would impair seal operation, including distortion that may occur during tightening of the bolts or nuts.

6.9.10 The mating joint between the seal gland and the seal chamber face shall incorporate a confined gasket to prevent blowout. The gasket shall be of the controlled compression type (O-ring or spiral-wound gasket) with metal to metal gland to seal-chamber contact. If space or design parameters make this requirement impractical, an alternative seal gland design shall be submitted to the purchaser for approval.

6.9.11 Specified seal and pump connections shall be identified by symbols permanently marked on the component. Symbols shall be in accordance with those specified in API 682/ISO 21049. If a seal gland utilizes a common design with multiple ports for symmetrical installation on multiple shaft pumps (right and left), the ports shall be appropriately identified.

6.9.12 Seal glands and seal chambers shall have provision for only those connections required by the seal flush plan. If other tapped connections are present but not used, they shall be plugged and labeled in accordance with API 682/ISO 21049.

6.9.13 The seal chamber shall be provided with an internal or external vent to permit complete venting of the chamber before start-up.

6.9.14 If seal flushing and cooling is provided by the pumped fluid, the pump vendor shall ensure that sufficient flow reaches the primary seal faces to provide for cooling and maintenance of a stable film at the seal faces. Allowance for cooling flow must be made when determining the pump capacity to meet delivered flow requirements.

6.9.15 If an external source of seal flushing is provided by the purchaser, the pump vendor shall specify the flow, pressure, temperature, and required lubricating properties of the flushing medium. If a restriction orifice is used, it shall not be less than 3 mm (0.12 in.) in diameter.

● **6.9.16** If specified, jackets shall be provided on seal chambers for heating. Heating requirements shall be agreed upon by the purchaser, pump manufacturer, and seal manufacturer.

6.9.17 If cooling is required, unless otherwise specified, air cooling shall be provided.

6.9.18 Unless otherwise specified, mechanical seals shall be installed in the pump prior to shipment and shall be clean, lubricated, and ready for service. If seals require final adjustment or installation in the field, a metal tag shall be attached warning of this requirement.

● **6.9.19** If specified, in dual seal applications, the maximum seal leakage to atmosphere at the specified operating conditions, and the expected inner seal-oil leakage rates, if applicable, shall be provided.

NOTE This information is required to determine the rate of barrier or buffer seal oil usage and thus the sizing of the seal oil reservoir.

6.10 Bearings and Bearing Housings

6.10.1 Antifriction bearings shall have a minimum L-10 rated life (see AFBMA 9) of either 25,000 hours with continuous operation at rated conditions, or 16,000 hours at maximum axial and radial loads and rated speed. These L-10 lives shall also apply for belt driven pumps.

NOTE 1 The rated life is the number of hours at rated bearing load and speed that 90 % of the group of identical bearings will complete or exceed before the first evidence of failure. It is recognized that this life may not be achieved where bearings are operated in fluids other than clean lubricating oil.

NOTE 2 In twin screw MPPs, the bearings must be sized and selected to manage the full radial load applied to the shaft, since hydrodynamic fluid film support between the rotor and liner may not be available. Special attention should also be given to minimum loading conditions to ensure that bearing skidding does not occur.

6.10.2 Except for the angular contact type, antifriction bearings shall have a loose internal clearance fit equivalent to AFBMA Symbol 3, as defined in AFBMA 20. Tapered roller bearings shall have a clearance fit as described in AFBMA 11. Single or double-row bearings shall not be supplied with filling slots.

NOTE 1 Greater internal clearances may reduce the temperature rise of the lubricant. However, vibration velocities may be increased with greater clearances.

NOTE 2 For the purpose of this provision, AFBMA 20 Group 3 is equivalent to ISO 5753 Group 3.

6.10.3 Housings for separately lubricated bearings shall be sealed against external contaminants. Such housings for oil-lubricated bearings shall contain a drain at the low point and shall be equipped with an oil-level gauge.

6.10.4 If regreaseable type lubricated bearings are supplied, the manufacturer's design shall include a provision to protect against over greasing.

6.10.5 Rolling element bearings shall be located, retained and mounted in accordance with the following.

6.10.5.1 Bearings shall be retained on the shaft with an interference fit and fitted into the housing with a diametral clearance, both in accordance with the recommendations of AFBMA 7, or as recommended by the bearing manufacturer.

6.10.5.2 Bearings shall be mounted directly on the shaft. Bearing carriers are acceptable only with customer approval.

6.10.5.3 Bearings shall be located on the shaft using shoulders, collars or other positive locating devices; snap rings and spring-type washers are not acceptable.

NOTE This paragraph applies to all rolling element bearings, including both ball and roller types. For certain roller bearings, such as cylindrical roller types with separable races, bearing housing diametral clearance may not be appropriate.

6.11 Vibration Limits

6.11.1 Vibration Limits for Liquid Pumps

Measurement on Bearing Housing	Rolling Element Bearings
Steady state vibration at any speed within operating range on test or in the field	V_u < 3.8 mm/s RMS (0.15 in./s RMS)

where

V_u is the unfiltered velocity;

RMS is the root mean squared.

6.11.2 Vibration Limits for Multiphase Pumps (MPPs)

Measurement on Bearing Housing	Rolling Element Bearings
For full liquid or any GVF on test	V_u < 7.1 mm/s RMS (0.28 in./s RMS)
Steady state vibration at any speed within operating range in the field	V_u < 5.5 mm/s RMS (0.22 in./s RMS)

where

V_u is the unfiltered velocity;

RMS is the root mean squared.

6.12 Lubrication

6.12.1 Lubrication for Rotary Pumps

6.12.2 If internal bearings and/or internal timing gears are used, the pump vendor shall verify that the pumped fluid will provide suitable lubrication.

6.12.3 Unless otherwise specified for twin screw pumps, bearings and bearing housings shall be splash lubrication and designed for mineral (hydrocarbon) oil.

6.12.4 Sufficient cooling, including an allowance for fouling, shall be provided to maintain oil and bearing life.

6.12.5 Based on the specified operating conditions and an ambient temperature of 43 °C (110 °F), oil lubrication temperatures shall be in accordance with 6.12.5 through 6.12.11.4.

6.12.5.1 For pressurized systems, oil outlet temperature below 70 °C (160 °F) and bearing metal temperatures (if bearing-temperature sensors are supplied) less than 93 °C (200 °F).

6.12.5.2 During shop testing, and under the most adverse specified operating conditions, the bearing-oil temperature rise shall not exceed 28 K (50 °R).

6.12.5.3 For ring-oiled or splash systems, oil sump temperature must be maintained below 82 °C (180 °F). During shop testing, the sump oil temperature rise shall not exceed 40 K (70 °R) and (if bearing-temperature sensors are supplied) outer ring temperatures shall not exceed 93 °C (200 °F).

NOTE Pumps equipped with ring-oiled or splash lubrication systems might not reach temperature stabilization during performance tests of short duration.

● **6.12.6** If specified, or as recommended by the pump vendor, the bearing lubrication may be splash, positive pressure, or gravity lubricated. A sight glass, gauge, or oil-level dipstick shall be provided.

6.12.7 Unless otherwise specified, pressurized oil systems shall conform to the requirements of the "General Purpose" section of ISO 10438-3.

NOTE For the purposes of this provision, Chapter 3 of API 614 is equivalent to ISO 10438-3.

● **6.12.8** If specified or if recommended by the vendor and approved by the purchaser, a pressure lubrication system shall be provided to supply oil at a suitable pressure and temperature to the pump, the driver, and any other driven equipment, including gears.

6.12.9 External pressure lubrication systems shall comply with the requirements of ISO 10438-3.

NOTE For the purposes of this provision, Chapter 3 of API 614 is equivalent to ISO 10438-3.

● **6.12.10** If specified, the pressure lubrication system shall conform to the requirements of ISO 10438-2 (*Special-purpose oil systems*). For such a lubrication system, datasheets should be supplied.

NOTE For the purpose of this provision, Chapter 2 of API 614 is equivalent to ISO 10438-2.

● **6.12.11** If grease lubricated rolling-element bearings are specified, lubrication shall be in accordance with 6.12.11.1 through 6.12.11.4.

6.12.11.1 Grease life (relubrication interval) shall be estimated using the method recommended by the bearing manufacturer or an alternative method approved by the purchaser.

6.12.11.2 Grease lubrication shall not be used if the estimated grease life is less than 2000 hours.

6.12.11.3 If the estimated grease life is 2000 hours or greater, but less than 25,000 hours, provision shall be made for re-greasing the bearings in service and for the effective discharge of old or excess grease, and the vendor shall advise the purchaser of the required re-greasing interval.

6.12.11.4 If the estimated grease life is 25,000 hours or more, grease nipples or any other system for the addition of grease in-service shall not be fitted.

6.13 Materials

6.13.1 Material Inspection of Pressure-containing Parts

6.13.1.1 Regardless of the generalized limits presented in this section, it shall be the vendor's responsibility to review the design limits of all materials and welds in the event that more stringent requirements are required.

6.13.1.2 Defects that exceed the limits imposed in 6.13.3 and 6.13.4 shall be removed to meet the quality standards cited, as determined by additional magnetic particle or liquid penetrant inspection as applicable before repair welding.

NOTE See 8.2.2.1.1.

6.13.1.3 The purchaser shall be notified before making a major repair to a pressure containing part. Major repairs, for the purpose of purchaser notification only, is any defect that equals or exceeds any of the three criteria defined below:

a) depth of the cavity prepared for repair welding exceeds 50 % of the component wall thickness;

b) length of the cavity prepared for repair welding is longer than 150 mm (6 in.) in any direction;

c) total area of all repairs to the part under repair exceeds 10 % of the surface area of the part.

6.13.1.4 All repairs to pressure containing parts shall be made as required by the following documents:

a) the repair of plates, prior to fabrication, shall be performed in accordance with the ASTM standard to which the plate was purchased;

b) the repair of castings or forgings shall be performed prior to final machining in accordance with the ASTM standard to which the casting or forging was purchased;

c) the inspection of a repair of a fabricated casing or the defect in either a weld or the base metal of a cast or fabricated casing, uncovered during preliminary or final machining, shall be performed in accordance with 8.2.2.1.1.

6.13.2 Materials of Construction

6.13.2.1 Unless otherwise specified, the materials of construction of the pressure-containing casing shall be carbon steel as a minimum.

6.13.2.2 The materials shall be the vendor’s standard for the operating conditions specified, except as required by the datasheet or this standard.

6.13.2.3 The materials of construction of all major components shall be clearly stated in the vendor's proposal. Materials shall be identified by reference to applicable international standards, including the material grade. If no such designation is available, the vendor's material specification, giving physical properties, chemical composition, and test requirements shall be included in the proposal.

● **6.13.2.4** If specified, copper or copper alloys shall not be used for parts which are in contact with process fluids. Nickel-copper alloy (UNS NW 4400 or UNS N04400), bearing babbitt, and copper-containing precipitation-hardened stainless steels are excluded from this requirement.

Warning—Certain corrosive fluids in contact with copper alloys have been known to form explosive compounds.

6.13.2.5 The vendor’s response to the inquiry shall specify the optional tests and inspection procedures that are necessary to ensure that materials are satisfactory for the service. Such tests and inspections shall be listed in the proposal.

NOTE The purchaser may specify additional optional tests and inspections, especially for materials used for critical components or in critical services.

6.13.2.6 External parts that are subject to rotary or sliding motions (such as control linkage joints and adjustment mechanisms) shall be of corrosion resistant materials suitable for the site environment.

6.13.2.7 Minor parts such as nuts, springs, washers, gaskets, and keys shall have corrosion resistance at least equal to that of specified parts in the same environment.

● **6.13.2.8** The purchaser shall specify any erosive or corrosive agents (including trace quantities) present in the process fluids and in the site environment, including constituents that may cause stress-corrosion cracking or attack elastomers.

NOTE Typical agents of concern are hydrogen sulfide, amines, chlorides, bromides, iodides, cyanides, fluorides, naphthenic acid and polythionic acid. Other agents affecting elastomer selection include ketones, ethylene oxide, sodium hydroxide, methanol, benzene and solvents.

6.13.2.9 If austenitic stainless steel parts exposed to conditions that may promote inter-granular corrosion are to be fabricated, hard-faced, overlaid or repaired by welding, they shall be made of low-carbon or stabilized grades.

NOTE Overlays or hard surfaces that contain more than 0.10 % carbon can sensitize both low-carbon and stabilized grades of austenitic stainless steel unless a buffer layer that is not sensitive to intergranular corrosion is applied.

● **6.13.2.10** If specified, the vendor shall furnish material certificates that include chemical analysis and mechanical properties for the heats from which the material is supplied for pressure-containing castings, forgings and shafts. Unless otherwise specified, piping nipples, auxiliary piping components, and bolting are excluded from this requirement.

6.13.2.11 If mating parts such as studs and nuts of austenitic stainless steel or materials with similar galling tendencies are used, they shall be lubricated with an antiseizure compound of the proper temperature specification and compatible with the specified process liquid.

NOTE The torque loading values to achieve the necessary preload are likely to vary considerably depending upon whether or not an anti-seizure compound is used.

● **6.13.2.12** The purchaser shall specify the amount of wet H_2S that may be present, considering normal operation, start-up, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.

NOTE In many applications, small amounts of wet H_2S are sufficient to require materials resistant to sulfide stress-corrosion cracking. If there are trace quantities of wet H_2S known to be present, or if there is any uncertainty about the amount of wet H_2S that may be present, the purchaser should consider specifying that reduced hardness materials are required.

● **6.13.2.13** The purchaser shall specify if reduced hardness materials are required.

6.13.2.13.1 If reduced hardness materials are specified in 6.13.2.13, they shall be supplied in accordance with NACE MR 0103 or MR 0175 (ISO 15156).

NOTE 1 NACE MR 0103 applies to oil refineries, LNG plants and chemical plants. NACE MR 0103 applies to materials potentially subject to sulfide stress corrosion cracking.

NOTE 2 NACE MR 0175 applies to oil and gas production facilities and natural gas sweetening plants. NACE MR 0175 applies to materials potentially subject to sulfide stress corrosion cracking. NACE MR 0175 is equivalent to ISO 15156.

6.13.2.13.2 If reduced hardness materials are specified, ferrous material not covered by NACE MR 0103 or NACE MR 0175 (ISO 15156) shall have a yield strength not exceeding 620 N/mm^2 (90,000 psi) and a hardness not exceeding HRC 22. Components that are fabricated by welding shall be postweld heat treated, if required, so that both the welds and heat-affected zones meet the yield strength and hardness requirements.

6.13.2.13.3 If reduced hardness materials are specified, the following components shall have reduced hardness:

a) the pressure casing,

b) shafting (including wetted shaft nuts),

c) pressure-retaining mechanical seal components (excluding seal faces),

d) wetted bolting.

6.13.2.14 The vendor shall select materials to avoid conditions that may result in electrolytic corrosion. If such conditions cannot be avoided, the purchaser and the vendor shall agree on the material selection and any other precautions necessary.

NOTE If dissimilar materials with significantly different electrical potentials are placed in contact in the presence of an electrolytic solution, galvanic couples may be created that can result in serious corrosion of the less noble material. The NACE *Corrosion Engineer's Reference Book* is one resource for selection of suitable materials in these situations.

6.13.2.15 Steel made to a coarse austenitic grain size practice (such as ASTM A515) shall not be used. Only fully killed or normalized steels made to fine grain practice shall be used.

6.13.2.16 The manufacturer's data report forms, as specified in codes such as ASME *BPVC S*ection VIII, are not required.

NOTE For impact requirements refer to 6.13.6.4.

● **6.13.2.17** The material specification of all gaskets and O-rings exposed to the pumped fluid shall be identified in the proposal. O-rings shall be selected and their application limited in accordance with ISO 21049. O-ring materials shall be compatible with all specified services. Special consideration shall be given to the selection of O-rings for high-pressure services to ensure that they will not be damaged upon rapid depressurization (explosive decompression). It shall be specified on the datasheet if the service is such that there is a risk of rapid depressurization.

NOTE 1 For the purpose of this provision, API 682 is equivalent to ISO 21049.

NOTE 2 Susceptibility to explosive decompression depends on the gas to which the O-ring is exposed, the compounding of the elastomer, temperature of exposure, the rate of decompression, and the number of cycles.

6.13.2.18 The minimum quality bolting material for pressure-retaining parts shall be carbon steel (such as ASTM A307, Grade B) for cast iron casings; and high temperature alloy steel (such as ASTM A193, Grade B7) for steel casings. Carbon steel nuts (such as ASTM A194, Grade 2H) shall be used, except that case hardened carbon steel nuts (such as ASTM A563, Grade A) shall be used where space is limited. For temperatures below –29 °C (–20 °F), low-temperature bolting material (such as ASTM A320) shall be used.

6.13.3 Castings

6.13.3.1 Castings shall be sound and free from porosity, hot tears, shrink holes, blow holes, cracks, scale, blisters, and similar injurious defects in excess of that specified in the material specification or any additional specified acceptance criteria (see 8.2.2).

6.13.3.2 Surfaces of castings shall be cleaned by sandblasting, shot-blasting, chemical cleaning, or other standard methods to meet the visual requirements of MSS SP-55. Mold-parting fins and the remains of gates and risers shall be chipped, filed or ground flush.

6.13.3.3 The use of chaplets in pressure castings shall be held to a minimum. If chaplets are necessary, they shall be clean and corrosion free (plating is permitted) and of a composition compatible with the casting.

6.13.3.4 Ferrous pressure-containing castings shall not be repaired by welding, peening, plugging, burning in, or impregnating, except as follows.

a) Weldable grades of steel castings may be repaired by welding in accordance with 6.13.5. Weld repairs shall be inspected according to the same quality standard used to inspect the casting.

b) All other repairs shall be subject to the purchaser's approval.

6.13.3.5 Fully enclosed cored voids, which become fully enclosed by methods such as plugging, welding, or assembly, are prohibited.

● **6.13.3.6** If specified, for casting repairs made in the vendor's shop, repair procedures including weld maps, shall be submitted for purchaser's approval. The purchaser shall specify if approval is required before proceeding with repair. Repairs made at the foundry level shall be controlled by the casting material specification ("producing specification").

6.13.3.7 Pressure-retaining castings of carbon steel shall be furnished in the normalized and tempered condition.

6.13.4 Forgings

6.13.4.1 Pressure-containing ferrous forgings shall not be repaired except as stated below.

a) Weldable grade of steel forgings may be repaired by welding in accordance with 6.13.5. After major weld repairs, and before hydrotest, the complete forging shall be given a postweld heat treatment to ensure stress relief and continuity of mechanical properties of both weld and parent metal.

b) All repairs that are not covered by the material specification shall be subject to the purchaser's approval.

6.13.5 Welding

● **6.13.5.1** Welding and weld repairs shall be performed in accordance with Table 3. If specified, alternative standards may be proposed by the vendor for the purchaser's approval and, if so, they shall be referenced in the datasheets (see Annex A).

Table 3—Welding Requirements

Requirement	Applicable Code or Standard
welder/operator qualification	ASME *BPVC* Section IX or EN 287
welding procedure qualification	applicable material specification or, where weld procedures are not covered by the material specification ASME *BPVC* Section IX or EN 288
non-pressure-retaining structural welding such as mounting plates or supports	AWS D1.1
magnetic particle or liquid penetrant examination of the plate edges	ASME *BPVC* Section VIII, Division 1, UG-93(d)(34)
postweld heat treatment	applicable material specification or ASME *BPVC* Section VIII, Division 1, UW 40

6.13.5.2 The vendor shall be responsible for the review of all repairs and repair welds to ensure that they are properly heat treated and nondestructively examined for soundness and compliance with the applicable qualified procedures (see 6.13.5.1). Repair welds shall be nondestructively tested by the same method used to detect the original flaw; however, the minimum level of inspection after the repair shall be by the magnetic particle method in accordance with 8.2.2.1.

6.13.5.3 Pressure-containing parts made of wrought materials or combinations of wrought and cast materials shall conform to the conditions specified below in 6.13.5.3 a) through 6.13.5.3. c). These requirements do not apply to casing nozzles and auxiliary connections; see 6.13.5.4.

a) Accessible surfaces of welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after postweld heat treatment or, for austenitic stainless steels, after solution annealing.

b) Pressure-containing welds, including welds of the casing to axial-joint and radial-joint flanges, shall be full-penetration welds.

c) If dimensional stability of such casing component must be assured for the integrity of pump operation, then postweld heat treatment shall be performed regardless of thickness.

d) Plate edges shall be inspected by magnetic particle or liquid penetrant examination as required by internationally recognized standards such as Section VIII, Division 1, UG-93 (d)(3), of the ASME Code.

● **6.13.5.4** Connections welded to casings shall be installed as follows.

a) Attachment of suction and discharge nozzles shall be by means of full-fusion, full-penetration welds. Weld neck flanges, or socket weld flanges, if approved by the purchaser, shall be used for pumps handling flammable or hazardous liquids. Welding of dissimilar metals shall not be performed.

b) If specified, proposed connection designs shall be submitted for purchaser approval before fabrication. The drawings shall show weld designs, size, materials, and pre and postweld heat treatments.

c) Postweld heat treatment, if required, shall be carried out after all welds, including piping welds, have been completed.

d) Unless otherwise specified, auxiliary piping welded to alloy steel casings shall be of a material with the same nominal properties as the casing material.

6.13.6 Low-temperature Service

● **6.13.6.1** The purchaser shall specify the minimum design metal temperature and concurrent pressure that the pump will be subjected to in-service. This temperature shall be used to establish impact test requirements.

NOTE Normally, this will be the lower of the minimum surrounding ambient temperature or minimum fluid pumping temperature; however, the purchaser may specify a minimum design metal temperature based on properties of the pumped fluid, such as auto-refrigeration at reduced pressures.

6.13.6.2 To avoid brittle failures, materials and construction for low-temperature service shall be suitable for the minimum design metal temperature in accordance with the codes and other requirements specified. The purchaser and the vendor shall agree on any special precautions necessary with regard to conditions that may occur during operation, maintenance, transportation, erection, commissioning and testing.

6.13.6.3 Care shall be taken in the selection of fabrication methods, welding procedures, and materials for vendor provided steel pressure retaining parts that may be subject to temperatures below the ductile-brittle transition temperature. The published design-allowable stresses for materials in internationally recognized standards such as the ASME Code and ANSI standards are based on minimum tensile properties. Some standards do not differentiate between rimmed, semikilled, fully killed, hot-rolled, and normalized material, nor do they take into account whether materials were produced under fine- or course-grain practices. Therefore, the vendor should exercise caution in the selection of materials intended for services between –29 °C (–20 °F) and 40 °C (100 °F).

● **6.13.6.4** The purchaser shall specify whether ASME *BPVC* Section VIII, Division 1, shall apply with regard to impact-testing requirements.

● **6.13.6.5** If ASME *BPVC* Section VIII, Division 1, is specified (see 6.14.6.3), the following shall apply:

a) all pressure-retaining steels applied at a specified minimum design metal temperature below –29 °C (–20 °F) shall have a Charpy V-notch impact test of the base metal and the weld joint unless they are exempt in accordance with ASME *BPVC* Section VIII, Division 1, UHA-51;

b) carbon steel and low alloy steel pressure-retaining parts applied at a specified minimum design metal temperature between –29 °C (–20 °F) and 40 °C (100 °F) shall require impact testing as stated below.

1) Impact testing is not required for parts with a governing thickness of 25 mm (1 in.) or less.

2) Impact testing exemptions for parts with a governing thickness greater than 25 mm (1 in.) shall be established in accordance with Paragraph UCS-66 in ASME *BPVC* Section VIII, Division 1. Minimum design metal temperature without impact testing may be reduced as shown in Figure UCS-66.1. If the material is not exempt, Charpy V-notch impact test results shall meet the minimum impact energy requirements of Paragraph UG-84 of the ASME Code.

6.13.6.6 Governing thickness used to determine impact testing requirements shall be the greater of the following.

a) The nominal thickness of the largest butt-welded joint.

b) The largest nominal section for pressure containment, excluding:

1) structural support sections such as feet or lugs;

2) sections with increased thickness required for rigidity to mitigate deflection;

3) structural sections required for attachment or inclusion of mechanical features such as jackets or seal chambers.

c) One fourth of the nominal flange thickness, (in recognition that the predominant flange stress is not a membrane stress).

6.14 Nameplates and Rotation Arrows

6.14.1 A nameplate shall be securely attached at a readily visible location on the equipment and on any other major piece of auxiliary equipment.

6.14.2 Rotation arrows shall be cast in or attached to each major item of rotating equipment in a readily visible location. Nameplates and rotation arrows (if attached) shall be of ANSI Standard Type 300 stainless steel or of nickel-copper alloy (Monel®[16] or its equivalent). Attachment pins shall be of the same material. Welding is not permitted.

6.14.3 The purchaser's item number, the vendor's name, the machine's serial number, and the machine's size and type, as well as its minimum and maximum allowable design limits and rating data (including pressures, temperatures, speeds, and power), MAWPs and temperatures, hydrostatic test pressures and critical speeds, shall appear on the machine's nameplate. The purchaser will specify on the datasheet whether USC or SI units are to be shown.

7 Accessories

7.1 Drivers

7.1.1 General

● **7.1.1.1** The type of driver shall be specified. The driver shall be designed and sized to meet all the specified operating conditions, including external gear and/or coupling losses, and shall be in accordance with applicable specifications, as stated in the inquiry and order. The driver shall be sized for satisfactory operation under the utility and site conditions specified.

[16] This term is used as an example only, and does not constitute an endorsement of this product by API.

NOTE 1 For electric motors, normally this is achieved by specifying constant torque. For engine drivers, which are never constant torque, the torque provided must meet 7.1.1.1 as above.

NOTE 2 For multiphase fluids, often the maximum driver requirement may be on 100 % liquid service. If slug flow is anticipated this should be brought to the attention of the vendor on the datasheets because this condition could be the maximum driver requirement. The purchaser should comment about these, or other special conditions, in a note in the datasheets.

7.1.1.2 The driver shall be sized to meet all process variations such as changes in the pressure, temperature, or properties of the fluid handled, and conditions specified in the inquiry, including plant start-up conditions.

7.1.1.3 The driver shall be capable of starting under the conditions specified and the starting method shall be agreed by the purchaser and the vendor. The driver's starting-torque capabilities shall exceed the speed-torque requirements of the driven equipment by a minimum of 10 %.

7.1.1.4 The supporting feet of drivers with a weight greater than 250 kg (550 lb) shall be provided with vertical jackscrews.

7.1.2 Motors

7.1.2.1 Motor drives shall conform to internationally recognized standards such as API 541, API 546, or API 547 as applicable. Motors that are below the power scope of API 541, API 546, or API 547 shall be in accordance with IEEE 841. For applications that utilize an adjustable speed drive, coordination between the pump, motor, and adjustable speed drive vendors may be required. The motor rating shall be at least 110 % of the greatest power required (including gear and/or coupling losses) for any of the specified operating conditions. The motor nameplate rating, including service factor, shall be suitable for operation at 100 % of the PLV accumulation pressure. Consideration shall be given to the starting conditions of both the driver and driven equipment and the possibility that these conditions may be different from the normal operating conditions. Equipment driven by induction motors shall be rated at the actual motor speed for the rated load conditions.

NOTE 1 The 110 % applies to the design phase of a project. After testing, this margin might not be available due to performance tolerances of the driven equipment.

NOTE 2 Electric motor drivers in accordance with IEEE 841 have a service factor of 1.0 for constant speed services. Motors in accordance with API 541, API 546, and API 547 have a standard service factor of 1.0; however, many users of these motors prefer to use a 1.15 service factor.

NOTE 3 Where possible, the electrical adjustable speed drive and motor should be purchased from the same vendor.

• **7.1.2.2** The purchaser shall specify the type of motor and its characteristics and accessories, including but not limited to the following:

a) electrical characteristics;

b) starting conditions (including the expected voltage drop on starting);

c) type of enclosure;

d) electrically insulated bearings, if required;

e) sound pressure level;

f) area classification, based on API 500 or equivalent international standard;

g) class of winding insulation;

h) required service factor;

i) ambient temperature and elevation above sea level;

j) transmission losses, if any;

k) temperature detectors, vibration sensors, and heaters, if any;

l) auxiliaries (such as motor-generator sets, ventilation blowers, and instrumentation);

m) vibration acceptance criteria;

n) use in adjustable speed drive applications.

7.1.2.3 Unless otherwise specified, the motor's starting torque shall be capable of accelerating the pump to rated speed at a voltage of 80 % of the nominal voltage.

7.1.2.4 Motors for belt drives shall be of extended-shaft construction and shall be suitable for the side loads imposed by the drive, taking into account the width of the bushing.

7.1.3 Steam Turbines

7.1.3.1 Steam turbine drivers shall conform to API 611. Steam turbine drivers shall be sized to deliver continuously not less than 110 % of the maximum power requirement of the driven equipment, (including all gear and/or coupling losses), when operating at any of the specified operating conditions, with the specified normal steam conditions. The maximum power requirement includes operation at 100 % of the PLV accumulation pressure.

NOTE The 110 % applies to the design phase of the project. After testing, this margin might not be available due to performance tolerances of the driven equipment.

7.1.4 Gear Units

7.1.4.1 Gear units integral with motor drivers are acceptable only if the driver nameplate rating is 18 kW (25 hp) or less. These integral gear units shall conform to AGMA 6091.

● **7.1.4.2** Coupled gears shall be either single helical or double helical type and shall conform to AGMA 6010. If specified, gear units shall conform to API 677.

7.1.4.3 The gear service factor shall be mutually agreed upon by both the gear and pump manufacturers for given service conditions such as torsional critical speeds. The gear service factor shall be subject to approval by the purchaser. In no case shall the service factor be less than that required by the latest editions of AGMA 6013 for standard gear reducers and/or API 613 or API 677 as specified.

7.2 Couplings and Guards

7.2.1 Unless otherwise specified, flexible couplings and guards between drivers and driven equipment shall be supplied by the manufacturer of the driven equipment.

7.2.2 Unless otherwise specified, all-metal-flexible element, spacer-type couplings manufactured to meet AGMA 9000 Class 9 shall be provided. Additionally, couplings shall comply with the items below.

a) Flexible elements shall be of corrosion-resistant material.

b) Couplings shall be designed to retain the spacer if a flexible element ruptures.

c) Coupling hubs shall be steel.

d) The distance between the pump and driver shaft ends (distance between shaft ends, or DBSE) shall be at least 125 mm (5 in.) and shall permit removal of the coupling, bearings and seal, as applicable, without disturbing the driver, driver coupling hub or the suction and discharge piping. This dimension, DBSE, shall always be greater than the minimum total seal length. The DBSE dimension usually corresponds to the nominal coupling spacer length.

e) The maximum shaft thermal growth shall not exceed the allowable disc pack compression to avoid transmitting thrust loads to the pump and driver bearings.

f) Provision shall be made for the attachment of alignment equipment without the need to remove the spacer or dismantle the coupling in any way.

NOTE One way of achieving this is to provide at least 25 mm (1 in.) of bare shaft between the coupling hub and the bearing housing where alignment brackets may be located.

● **7.2.3** If specified, couplings shall be balanced to AGMA 9000 Class 10.

● **7.2.4** If specified, couplings shall meet the requirements of ISO 14691, ISO 10441, or API 671.

● **7.2.5** If specified, electrically insulated couplings shall be provided.

7.2.6 Information on shafts, keyway dimensions (if any), and shaft end movements due to end play and thermal effects shall be furnished to the vendor providing the coupling.

7.2.7 Flexible couplings shall be keyed to the shaft. Keys, keyways, and fits shall conform to AGMA 9002, "Commercial Class." Shaft coupling keyways shall be cut to accommodate a rectangular cross section key. Keys shall be fabricated and fitted to minimize unbalance.

7.2.8 Couplings and coupling to shaft junctures shall be rated for at least the maximum driver power, including the driver service factor.

7.2.9 For shaft diameters greater than 60 mm (2.5 in.) and if it is necessary to remove the coupling hub to service the mechanical seal, the hub shall be mounted with a taper fit and capable of transmitting the maximum torque. The coupling fit taper shall be 1 in 16 [60 mm/m (0.75 in./ft), diametral]. Other mounting methods and tapers shall be agreed upon by the purchaser and the vendor. Appropriate assembly and maintenance procedures should be used to assure that taper fit couplings have an interference fit.

7.2.10 Coupling hubs with cylindrical bores may be supplied with slip fits to the shaft and set-screws that bear on the key. Slip fits on cylindrical bores allow adjustment of the coupling axial position in the field without application of heat.

7.2.11 Coupling hubs designed for interference fits to the shaft shall be furnished with tapped puller holes at least 10 mm (0.38 in.) in diameter to aid in removal.

● **7.2.12** If specified, coupling hubs shall be fitted hydraulically.

7.2.13 If the driven-equipment vendor is not required to mount the driver, the coupling purchaser shall deliver the fully machined half-coupling to the driver manufacturer's plant or any other designated location, together with the necessary instructions for mounting the half-coupling on the driver shaft.

7.2.14 If the driver is a horizontal sleeve-bearing motor, limited end-float couplings shall be supplied to prevent end contact between shoulders on the motor shaft and its bearings.

7.2.15 Each coupling shall have a guard, which is removable without disturbing the coupled elements and shall meet the requirements below.

a) Guards shall enclose the moving elements and the shafts to prevent personnel from contacting moving parts during operation of the equipment train. Allowable access dimensions shall comply with specified standards, such as ISO 14120 or EN 953.

b) Guards shall be constructed with sufficient rigidity to withstand a 900 N (200 lbf) static point load in any direction without the guard contacting moving parts.

● c) Guards shall be fabricated from either solid sheet or plate with no openings, or expanded metal or perforated sheets if the size of the openings does not exceed 10 mm (0.38 in.). Guards shall be constructed of steel, brass or nonmetallic (polymer) materials. Guards of woven wire shall not be used. If specified, non-sparking guards of agreed material shall be supplied.

7.3 Belt Drives

● **7.3.1** Belt drives shall only be used for equipment of 37 kW (50 hp) or less. Unless otherwise specified, banded multi-V belts shall be provided. If more than one banded multi-V belt is required, the vendor shall provide matched belt lengths. All belts shall be of the static-conducting type and shall be oil resistant. The drive service factor shall be in accordance with the service factor recommended by the manufacturer for the intended service, based on the driver nameplate power rating. If specified, a cog-belt type drive shall be provided. Details shall be mutually agreed upon between the vendor and the purchaser.

7.3.2 The vendor shall provide a positive belt-tensioning device. This device shall incorporate either a lateral adjustable base with guides and hold-down bolts, two belt-tensioning screws, and locking devices, or a vertical adjustable base with four belt-tensioning screws, each with a locking device. The belt-tensioning device adjustment range shall be sufficient to remove and replace belts without prying or forcing the belts off the sheaves and without moving the driver.

7.3.3 Belt drives shall meet the following requirements:

a) the distance between the centers of the sheaves shall be at least 1.5 times the diameter of the larger sheave;

b) the belt wrap (contact) angle on the smaller sheave shall be at least 140 °;

c) the shaft length on which the sheave hub is fitted shall be at least equal to the width of the sheave hub;

d) the length of a shaft key used to mount a sheave shall be equal to the length of the sheave bore;

e) unless otherwise agreed or specified, each sheave shall be mounted on a tapered adapter bushing;

f) to reduce the moment on shafts due to belt tension, the sheave overhang distance from the adjacent bearing shall be minimized;

g) sheaves shall meet the balance requirements of ISO 1940-1 or ASA S2.19, Grade 6.3.

7.3.4 For exposed belts, guards meeting the requirements of 7.2.15 shall be provided by the vendor.

7.3.5 MPPs shall be direct driven. The use of drive belts is not permissible.

7.4 Baseplates

● **7.4.1** If a baseplate is specified, the purchaser shall indicate the major equipment to be mounted on it. A baseplate shall be a single fabricated steel unit, unless the purchaser and the vendor mutually agree that it may be fabricated in multiple sections. A multiple section baseplate shall have machined and doweled mating surfaces which shall be bolted together to ensure accurate field reassembly.

NOTE A baseplate with a nominal length of more than 12 m (40 ft) or a nominal width of more than 4 m (12 ft) may have to be fabricated in multiple sections because of shipping restrictions.

● **7.4.2** If specified, the baseplate shall be designed for column mounting (that is, of sufficient rigidity to be supported at specified points) without continuous grouting under structural members. The baseplate design shall be mutually agreed upon by the purchaser and the vendor.

7.4.3 If a baseplate is provided, it shall extend under the drive-train components so that any leakage from these components is contained within the baseplate.

7.4.4 If a piece of equipment has a mass in excess of 250 kg (550 lb), the baseplate shall be supplied with horizontal (axial and lateral) jackscrews, the same size or larger than the vertical jackscrews. The lugs holding these jackscrews shall be attached to the baseplate in such a manner that they do not interfere with the installation of the equipment, jackscrews, spacers, or shims. Precautions shall be taken to prevent vertical jackscrews in the equipment feet from marring the shimming surfaces. Alternative methods of lifting equipment for the removal or insertion of shims or for moving equipment horizontally, such as provision for the use of hydraulic jacks, may be proposed. Such arrangements should be proposed for equipment that is too heavy to be lifted or moved horizontally using jackscrews. Jackscrews shall be stainless steel or plated for corrosion resistance.

7.4.5 Baseplates shall be designed to limit the relative displacement of the shaft end caused by the worst combination of pressure, torque and allowable piping stress, to 50 μm (0.002 in.). Loads applied during transportation and installation shall not cause permanent deformation (see 6.7 for allowable piping loads).

7.4.6 Baseplates shall conform to the following:

a) baseplates shall not be drilled for equipment to be mounted by others,

b) baseplates shall be supplied with leveling screws,

c) outside corners of baseplates which are in contact with the grout shall have 50 mm (2 in.) minimum radius outside corners (in the plan view),

d) all machinery mounting pads shall be treated with a rust preventive immediately after machining,

e) mounting pads shall extend at least 25 mm (1 in.) beyond the outer three sides of equipment feet,

f) mounting pads shall be machined to a finish of 3.2 (125 μin.) arithmetic average roughness (Ra) or smoother.

● **7.4.7** Mounting pads shall be provided for the pump and all drive train components, such as motors and gears. The pads shall be larger than the foot of the mounted equipment to allow levelling of the baseplate without removal of the equipment. The pads shall be fully machined flat and parallel. Corresponding surfaces shall be in the same plane within 150 μm/m (0.002 in./ft) of distance between the pads. If specified, this requirement shall be demonstrated in the pump vendor’s shop prior to mounting of the equipment and with the baseplate supported and clamped at the foundation bolt holes only.

NOTE Installed baseplate flatness may be affected by transportation, handling and installation procedures beyond the vendor's scope. Installation practices in API 686 should be followed. Because of the weight of the equipment, consideration should also be given to shipping the baseplate without the equipment mounted.

7.4.8 The underside of the fabricated decking located under the pump and drive train supports shall be continuous seal welded to the cross members.

7.4.9 The underside mounting surfaces of the baseplate shall be in one plane to permit use of a single-level foundation. If the baseplate is constructed of multiple sections, the mounting pads shall be in one plane after the baseplate sections are doweled and bolted together.

7.4.10 The baseplate shall be provided with lifting lugs for at least a four-point lift. Lifting the baseplate or skid complete with all equipment mounted shall not permanently distort or otherwise damage the baseplate or the equipment mounted on it. The vendor shall advise if a spreader bar is needed, and if equipment must be uncoupled before lifting.

7.4.10.1 The lifting lugs and attachment method shall be designed using a maximum allowable stress of one-third of the specified minimum yield strength of the material. Any lifting lug welds shall be inspected by either liquid penetrant or magnetic particle testing.

7.4.11 Baseplate shall be of the drain-rim or drain-pan type and shall have a raised lip. Connections for a drain shall be tapped DN 50 (NPS 2) minimum in the raised lip at the pump end and shall be located for complete drainage. The pan or upper surface of the baseplate shall be sloped 1:120 minimum toward the drain end.

● **7.4.12** If specified, nonskid metal decking covering all walk and work areas shall be provided on the top of the baseplate.

7.4.13 Unless otherwise specified, epoxy grout shall be used for baseplates designed for grouting when installed on concrete foundations. The vendor shall commercially sand blast, in accordance with ISO 8501-1 Grade Sa2 or SSPC SP 6, all grout contact surfaces of the baseplate and coat those surfaces with a primer compatible with epoxy grout. Grouts other than epoxy may require alternative surface preparation.

7.4.14 The bottom of the baseplate between structural members shall be open. If the baseplate is designed for grouting, it shall be provided with at least one grout hole having a clear area of at least 0.01 m^2 (20 $in.^2$) and no dimension less than 75 mm (3 in.) in each bulkhead section. These holes shall be located to permit grouting under all load carrying structural members. If practical, the holes shall be accessible for grouting with the equipment installed. If located in an area where liquids could impinge on the exposed grout, metallic covers with a minimum thickness of 16 gauge shall be provided for the grout holes. Vent holes at least 13 mm (0.5 in.) in size shall be provided at the highest point in each bulkhead section of the baseplate.

● **7.4.15** If specified, 13 mm (0.5 in.) raised-lip edges shall be provided around the grout holes.

NOTE This is particularly necessary for installations that will be using cementatious grout.

7.4.16 Unless otherwise specified, shims shall not be used under the pump. All pads for drive train components shall be machined to allow for the installation of stainless steel shims at least 3 mm (0.12 in.) thick under each component. If the vendor mounts the components, a set of shims at least 3 mm (0.12 in.) thick shall be supplied. Shim packs shall not be thicker than 13 mm (0.5 in.) nor contain more than 5 shims. All shim packs shall straddle the hold-down bolts and vertical jackscrews and extend at least 6 mm (0.25 in.) beyond the outer edges of the equipment feet. If the vendor does not mount the components, the pads shall not be drilled, and shims shall not be provided.

● **7.4.17** If specified, in addition to shim packs, a stainless steel spacer plate of not less than 6 mm (0.25 in.) thickness, machined on both sides, and of the same length and width as the specific mounting feet, shall be furnished and installed under all equipment feet, including the pump, driver, and any speed increaser or reducer.

● **7.4.18** If specified, the baseplate shall be designed to facilitate the use of optical, laser based or other instruments for accurate leveling in the field. The details of such facilities shall be agreed by the purchaser and vendor. Where the requirement is satisfied by the provisions of leveling pads and/or targets, they shall be accessible with the baseplate on the foundation and the equipment mounted. Removable protective covers shall be provided. For column mounted baseplate (see 7.4.2) leveling pads or targets shall be located close to the support points. For noncolumn mounted baseplate, a pad or target should be located at each corner. When required for long units, additional pads shall be located at intermediate points.

7.4.19 Equipment and baseplates shall be designed for installation in accordance with API 686.

7.4.20 Hold-down bolts used to attach the equipment to the baseplate, and all jackscrews, shall be provided by the vendor.

7.4.21 Unless otherwise specified, anchor bolts shall be supplied by the purchaser.

7.4.22 The anchor bolts shall not be used to fasten equipment to the baseplate.

7.5 Pressure-limiting Valves (PLVs)

7.5.1 PLVs or other protective devices shall be used with all positive displacement pumps. Rupture disks shall not be used. The sizing, selection and installation of pressure limiting valves shall meet the requirements of API 520, Part I and Part II.

7.5.2 Unless otherwise specified, the purchaser shall provide PLVs in accordance with API 526. The vendor shall provide the purchaser with information on recommended flow rate and relieving pressure. The vendor and purchaser should review the purchaser's valve selection. PLV sizes and settings, including accumulation, shall take into account all possible modes of equipment failure and shall meet the requirements of 6.3.2.

● **7.5.2.1** If specified, the valve shall be provided by the vendor.

7.5.3 Unless agreed to by the purchaser, pressure limiting valves that are integral with or internal to the pump are not acceptable.

7.6 Controls and Instrumentation

7.6.1 The controls and instrumentation scope of supply shall be supplied and installed as per the purchaser's specifications and on the datasheet.

NOTE See Annex G for a typical piping and instrumentation diagram for MPP skids.

7.6.2 All controls and instrumentation shall be per API 614/ISO 10438 and suitable for the electrical classification and the hazard conditions as identified on the datasheet.

7.7 Auxiliary Piping

7.7.1 Auxiliary piping, oil piping, instrument piping and process piping shall be in accordance with the appropriate part of API 614/ISO 10438, except as modified in 7.7.2.

NOTE For the purposes of this provision, API 614 (all parts) is equivalent to ISO 10438 (all parts).

7.7.2 Auxiliary piping system materials shall be in accordance with Table 10 of API 614/ISO 10438. If space does not permit the use of DN 12, DN 20, DN 25 (NPS $^1/_2$, NPS $^3/_4$, or NPS 1) pipe, seamless tubing may be supplied.

NOTE For the purposes of this provision API 5L (all parts) is equivalent to ISO 3183 (all parts).

7.7.2.1 A thermal relief valve piped to the purchaser's vent and drain system should be considered for auxiliary piping systems that can be blocked in by a valve closure.

7.7.3 Pipe plugs shall be in accordance with 6.5.4.3 for permanent plugs or 8.4.3.6 for shipping plugs.

7.8 Pulsation and Vibration Control Requirements for Multiphase Skids

7.8.1 General

The interaction of the dynamic flow generated by the MPP with acoustical resonance in piping systems can result in excitation in the pump and piping. This energy can result in pump and piping failures.

The responsiveness of a pump/piping system depend on factors such as the following:

a) complexity of the piping system layout,

b) number of pumps,

c) operating speeds,

d) rate of change of operating conditions,

e) pump type,

f) pump size (power),

g) number of screw leads (starts),

h) system operational conditions,

i) screw geometry, and

j) fluid properties.

7.8.2 To minimize the likelihood of detrimental vibrations in a pumping system, the pump vendor shall use basic techniques, including the following items.

a) The fluid properties and potential for slug flows (see Note 4 as follows).

b) Review comparable pumping applications.

c) For piping within their scope of supply, the pump vendor shall design the piping layout addressing the following:

   1) maintaining near-ground level routing of piping when possible to facilitate effective (relatively stiff) restraints;

   2) minimizing the number of direction and elevation changes to reduce the potential for coupling pulsations into a mechanical shaking force;

   3) using adequate dynamic restraints on pulsation suppression devices to ensure vibration control of these devices;

   4) using sufficient number of piping restraints (clamp spacing) and proper restraint design.

d) If specified by purchaser, conduct a dynamic simulation of the pumping system across the specified operating conditions.

NOTE 1 Clamps are preferred to U-bolts; weight-only type supports should be avoided.

NOTE 2 Normally control of system vibration needs coordination between the pump manufacturer and the piping system designer in order to ensure that the pump system characteristics meet the specified requirements.

NOTE 3 Dynamic simulation may be specified to be performed by a third-party entity.

NOTE 4 The vendor may be requested to comment on the purchaser's piping system that the pump will be part of (see Annex F).

7.9 Special Tools

7.9.1 If special tools or fixtures are required to disassemble, assemble or maintain the equipment, they shall be included in the quotation and provided as part of the initial supply of the equipment. For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be agreed between purchaser and vendor. These, or similar special tools, shall be used, and their use demonstrated, during shop assembly and any required post-test disassembly of the equipment.

7.9.2 If special tools are provided, they shall be firmly attached to the pump or packaged in a separate, rugged metal box or boxes and shall be marked "special tools for (tag/item number)." Each tool shall be stamped or tagged to indicate its intended use.

8 Inspection, Testing and Preparation for Shipment

8.1 General

● **8.1.1** The purchaser shall specify the extent of participation in the inspection and testing.

● **8.1.2** If specified, the purchaser's representative, the vendor's representative or both shall indicate compliance in accordance with an inspector's checklist such as that provided in Annex C by initialing, dating, and submitting the completed checklist to the purchaser before shipment.

8.1.3 After advance notification to the vendor, the purchaser's representative shall have entry to all vendor and sub-vendor plants where manufacturing, testing or inspection of the equipment is in progress.

8.1.4 The vendor shall notify sub-vendor of the purchaser's inspection and testing requirements.

● **8.1.5** If specified, the vendor shall provide their standard inspection and test plan (ITP) to the purchaser for review and acceptance.

● **8.1.6** If shop inspection and testing have been specified by the purchaser, the purchaser and the vendor shall coordinate manufacturing hold points and inspector's visits.

8.1.7 The expected dates of testing shall be communicated at least 30 days in advance and the actual dates confirmed as agreed. Unless otherwise agreed, the vendor shall give at least 5 working days advanced notification of a witnessed or observed inspection or test.

NOTE 1 For smaller pumps where set-up and test time is short, five days notice may require the pump to be removed from the test stand between preliminary and witness tests.

NOTE 2 All witnessed inspections and tests are hold points. For observed tests, the purchaser should expect to be in the factory longer than for a witnessed test.

● **8.1.8** If specified, witnessed mechanical and performance tests shall require a written notification of a successful preliminary test. The vendor and purchaser shall agree if the machine test set up is to be maintained or if the machine can be removed from the test stand between the preliminary and witnessed tests.

NOTE 1 Many purchasers prefer not to have preliminary tests prior to witnessed tests to understand any difficulties encountered during testing. If this is the case, purchasers should make it clear to the vendor.

NOTE 2 This is particularly important for MPPs.

8.1.9 Equipment, materials and utilities for the specified inspections and tests shall be provided by the vendor.

8.1.10 The purchaser's representative shall have access to the vendor's quality program for review and all major sub-vendors.

8.2 Inspection

8.2.1 General

8.2.1.1 The vendor shall keep the following data available for at least 20 years:

a) necessary or specified certification of materials, such as mill test reports;

b) test data and results to verify that the requirements of the specification have been met;

c) fully identified records of all heat treatment and nondestructive examination (NDE) whether performed in the normal course of manufacture or as part of a repair procedure;

d) results of quality control tests and inspections;

e) details of all major weld repairs including weld maps;

● f) if specified, final assembly maintenance and running clearances;

g) other data specified by the purchaser or required by applicable codes and regulations (see Section 5);

h) nonconformance reports and corrective actions.

8.2.1.2 Pressure-containing parts shall not be painted until the specified inspection and testing of the parts is complete.

● **8.2.1.3** In addition to the requirements of 8.2.2, the purchaser may specify the following:

a) parts that shall be subjected to surface and subsurface examination; and

b) the type of examination required, such as magnetic particle, liquid penetrant, radiographic and ultrasonic examination.

8.2.1.4 All running tests and mechanical checks shall be completed prior to the purchaser's final inspection.

8.2.2 Materials Inspection

8.2.2.1 General

8.2.2.1.1 NDE shall be performed as required by the material specification. If additional radiographic, ultrasonic, magnetic particle or liquid penetrant examination of the welds or materials is specified by the purchaser, the methods and acceptance criteria shall be in accordance with the standards shown in Table 4. Alternative standards may be proposed by the vendor or specified by the purchaser and they shall be mutually agreed to by both purchaser and vendor. The welding and material inspection datasheet in Annex A may be used for this purpose.

Table 4—Material Inspection Standards

Type of Inspection	Methods	Acceptance Criteria	
		For Fabrications	For Castings
visual inspection (Note 1)	ASME *BPVC* Section V, Article 9	Note 2	MSS SP-55
radiography	ASME *BPVC* Section V, Articles 2 and 22	ASME *BPVC* Section VIII, Division 1, UW-51 (for 100 % radiography) and UW-52 (for spot radiography)	ASME *BPVC* Section VIII, Division 1, Appendix 7
ultrasonic inspection	ASME *BPVC* Section V, Articles 5 and 23	ASME *BPVC* Section VIII, Division 1 Appendix 12	ASME *BPVC* Section VIII, Division 1, Appendix 7
magnetic particle inspection	ASME *BPVC* Section V, Articles 7 and 25	ASME *BPVC* Section VIII, Division 1, Appendix 6	ASME *BPVC* Section VIII, Division 1, Appendix 7
liquid penetrant inspection	ASME *BPVC* Section V, Articles 6,and 24	ASME *BPVC* Section VIII, Division 1, Appendix 8	ASME *BPVC* Section VIII, Division 1, Appendix 7

NOTE 1 For visual inspection all surfaces shall be inspected.

NOTE 2 Acceptance criteria for fabricated parts shall be in accordance with the material specification and the manufacturer's documented procedures.

8.2.2.1.2 Plate used in fabrications shall be inspected prior to starting fabrication in accordance with the material standard to which the plate was purchased.

8.2.2.1.3 The NDE should be done on finished machined surfaces (see Annex A datasheets).

● **8.2.2.1.4** If NDE testing is specified for nodular iron castings, it will be conducted using the magnetic particle and liquid penetrant test methods.

8.2.3 Mechanical Inspection

8.2.3.1 During assembly of the equipment, each component (including integrally cast-in passages) and all piping and auxiliaries shall be inspected to ensure they have been cleaned and are free of foreign materials, corrosion products and mill scale.

8.2.3.2 All oil system components supplied shall meet the cleanliness requirements of Part 3 of API 614/ISO 10438.

NOTE For the purposes of this provision ISO 10438-3 is equivalent to Part 3 of API 614.

● **8.2.3.3** If specified, the purchaser may inspect the equipment and all piping and auxiliaries for cleanliness before heads are welded onto vessels, openings in vessels or exchangers are closed, or piping is finally assembled.

● **8.2.3.4** If specified, the hardness of parts, welds, and heat-affected zones shall be verified as being within the allowable values by testing. The method, extent, documentation, and witnessing of the testing shall be mutually agreed upon by the purchaser and the vendor.

8.2.4 Positive Material Identification (PMI)

● **8.2.4.1** If PMI testing has been specified for a fabrication, the components comprising the fabrication, including welds, shall be checked after the fabrication is complete. Testing may be performed prior to any heat treatment.

● **8.2.4.2** If PMI is specified, techniques providing quantitative results shall be used.

8.2.4.3 Mill test reports, material composition certificates, visual stamps or markings shall not be considered as substitutes for PMI testing.

8.2.4.4 PMI results shall be within material specification governing standard(s) limits with allowance for the accuracy of the PMI device as specified by the device manufacturer.

8.3 Testing

8.3.1 General

8.3.1.1 Equipment shall be tested in accordance with 8.3.2, 8.3.3, or 8.3.4 as appropriate.

● **8.3.1.2** If specified, the vendor shall submit to the purchaser, for review and comment, detailed procedures and acceptance criteria for all required tests. The time period between submittal of the documents and the running test shall be at least six weeks, unless otherwise agreed.

8.3.1.3 Notification requirements are covered in 8.1.7, however, hydro and running test requirements shall be not less than five working days before the date the equipment will be ready for testing. If the testing is rescheduled, the vendor shall notify the purchaser not less than five working days before the new test date.

8.3.2 Hydrostatic Testing

8.3.2.1 All pressure casing components shall be assembled as a single unit and tested hydrostatically with liquid at a minimum of 1.5 times the MACP, but not less than a gauge pressure of 150 kPa (1.5 bar) (20 psi).

NOTE Casings with dual pressure ratings may be segmentally tested as per 8.3.2.7.

8.3.2.1.1 The test liquid shall be at a higher temperature than the ductile-brittle transition temperature of the material being tested.

NOTE The ductile-brittle transition temperature is the highest temperature at which a material experiences complete brittle fracture without appreciable plastic deformation.

8.3.2.2 If the component handling the pumped liquid is to operate at a temperature at which the strength of a material is below the strength of that material at the testing temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at the testing temperature by that at the rated operating temperature. The stress values used shall be determined in accordance with those of 6.3.1. For piping, the stress shall conform to ASME B31.3 or ISO 15649 as specified by the user. The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed. The vendor shall list actual hydrostatic test pressures on datasheets.

NOTE The applicability of this requirement to the material being tested should be verified before hydrotest, as the properties of many grades of steel do not change appreciably at temperatures up to 200 °C (390 °F).

8.3.2.3 If applicable, tests shall be in accordance with the code or standard to which the part has been designed. In the event that a discrepancy exists between the code test pressure and the test pressure in this standard, the higher pressure shall govern.

8.3.2.4 The chloride content of liquids used to test austenitic stainless steel materials shall not exceed 50 ppm (ppm by mass). To prevent deposition of chlorides on austenitic stainless steel as a result of evaporative drying, all residual liquid shall be removed from tested parts at the conclusion of the test.

NOTE Chloride content is limited in order to prevent stress corrosion cracking.

8.3.2.5 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when neither leaks nor seepage through the pressure containing part or joints is observed for a minimum of 30 minutes. Large, heavy pressure-containing parts may require a longer testing period to be agreed upon by the purchaser and the vendor. Gaskets used during the hydrostatic testing shall be of the same design as supplied with the pump. Seepage past internal closures required for testing of segmented cases and operation of a test pump to maintain pressure is acceptable (see 8.3.2.1).

8.3.2.6 All water-side cooling passages shall be tested at a minimum gauge pressure of 1000 kPa (10 bar) (150 psi).

8.3.2.7 Casings with dual pressure ratings may be segmentally tested. Seepage past internal closures or gaskets and operation of a test pump to maintain pressure is acceptable.

8.3.3 Pre-testing Check

8.3.3.1 Oil system components downstream of the filters shall meet the cleanliness requirements of ISO 10438-3 before any test is started.

NOTE For the purposes of this provision Part 3 of API 614 is equivalent to ISO 10438-3.

8.3.3.2 All joints and connections shall be checked for tightness and any leaks shall be corrected.

8.3.3.3 All warning, protective and control devices used during the test shall be checked and adjusted as required.

8.3.4 Performance Test

8.3.4.1 Unless otherwise specified, tests shall be conducted in accordance with Section 3.6 of the Hydraulic Institute pump standards, according to the tolerances specified in 8.3.6. The manufacturer shall operate the pump in their shop for sufficient period to obtain complete test data, including speed, discharge pressure, suction pressure, power, and capacity.

● **8.3.4.2** If specified, and if the pump is to be operated at variable speeds, the pump shall be tested at speeds within five percentage points of 30, 60, 90, and 100 of the rated speed.

8.3.4.3 The tests specified in 8.3.4.1 apply to the pump only, and the values of power are to be taken as referring to the pump. However, the recorded data and final report may include information on the complete unit, including driver and auxiliary equipment. The purchaser and the vendor shall agree to the test measurements to be recorded on both the driver and the auxiliary equipment.

8.3.4.3.1 If the test facility does not have the capability to meet the rated conditions, the tests shall be run at both the specified discharge pressure with reduced speed and at the rated speed with reduced discharge pressure. The purchaser and the vendor shall agree to the test methods and their limitations prior to performing the tests.

8.3.4.4 If dismantling is necessary to correct pump deficiencies, the pump characteristics affected by the correction shall be reestablished by testing.

8.3.5 Mechanical Run Test

● **8.3.5.1** If specified, a mechanical run test shall be performed either before or consecutively following the performance test. The mechanical run test shall be one hour or until oil temperatures have stabilized.

● **8.3.5.2** If specified, the pump shall be mechanically run for four hours. Unless otherwise specified or agreed, this shall be performed at the rated flow.

8.3.5.3 Unless otherwise agreed, the contract shaft seals and bearings shall be used in the machine for the mechanical running test.

8.3.5.4 If replacement or modification of bearings or seals or dismantling of the case to replace or modify other parts is required to correct mechanical or performance deficiencies, the initial test will not be acceptable and the final shop tests shall be run after these deficiencies are corrected.

8.3.6 Test Tolerances

Unless otherwise agreed or specified, when operated on the test stand, pumps shall be within the tolerances as given in Table 5.

Table 5—Test Tolerances

Characteristic Capacity	Tolerance (%)
at 100 % speed	+3, –0 of rated capacity
at 90 % speed	+3, –0 of rated capacity
at 60 % speed	+5, –0 of rated capacity
at 30 % speed	+10, –0 of rated capacity
rated power (at rated pressure and capacity)	+4
NPSHR (at rated capacity)	+0

● 8.3.7 Optional Tests

If specified, the shop tests described in 8.3.7.1 through 8.3.7.4 shall be performed. Test details shall be mutually agreed upon by the purchaser and the vendor.

● 8.3.7.1 NPIP/NPSH Test

If specified, the pump shall be tested for NPSH. At rated speed and with NPSHA equal to quoted NPSHR, the pump capacity shall be within three percent of the non-cavitating capacity.

Warning—The pump shall not be run while cavitating.

NOTE 1 The vendor must confirm if the mechanical seal included in their scope can operate in a suction lift condition.

NOTE 2 NPIP/NPSH testing is not applicable for MPPs.

● 8.3.7.2 Complete Unit Test

If specified, such components as pumps, gears, drivers and auxiliaries that make up the complete unit shall be tested together. The complete unit test may be performed in place of or in addition to separate tests of individual components.

● **8.3.7.3 Sound Level Test**

If specified, the sound level test shall be performed in accordance with ISO 3744 or other agreed standard.

● **8.3.7.4 High Discharge Pressure Test**

If specified, the pump will be operated at the PLV set pressure at the maximum rated pump speed and a fluid viscosity agreed to by the vendor and the purchaser to confirm that the pump does not seize under these conditions. A single data point will be collected.

8.3.8 Multiphase Tests

● **8.3.8.1 Multiphase Fluid Mechanical Test**

If specified, a fluid of defined GVF, simulating contract multiphase conditions, will be introduced into the pump/ pumping system inlet during this test. Data gathered is as per the mechanical run test. Test stand conditions and acceptance criteria shall be mutually agreed between the vendor and purchaser. The vendor shall provide a recommended test procedure as part of the proposal.

8.3.8.2 Gas Slug Test (Dry Run Test)

If specified, a slug test (rapid change from 30 % to 100 % GVF at pump/pumping system inlet) will be performed following the multiphase fluid mechanical test for the designed period of time. Data gathered is as per the multiphase fluid test. Test stand conditions and acceptance criteria shall be mutually agreed between the vendor and purchaser. The vendor shall provide a recommended test procedure as part of the proposal.

● **8.3.8.3 Factory Acceptance Test**

If specified, controls and instrumentation shall undergo a functional acceptance test, which includes verification of functionality of instrumentation, control, PLC control logic, alarm and shutdown set points.

8.3.9 Test Data

Immediately upon completion of each witnessed mechanical and performance test, copies of the data logged shall be given to the witness.

8.4 Preparation for Shipment

8.4.1 Equipment shall be suitably prepared for the type of shipment specified. Unless otherwise specified, the preparation shall make the equipment suitable for 6 months of outdoor storage from the time of shipment, with no disassembly required before installation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser will consult with the vendor regarding the recommended procedures to be followed. Removal of the inhibitor and periodic rotation of the pump shaft (per the vendor’s recommended procedure) to ease seal and bearing movement, shall be the responsibility of the purchaser.

8.4.2 The vendor shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up, as described in Chapter 3 of API 686.

8.4.3 The equipment shall be prepared for shipment after all testing and inspection has been completed and the equipment has been released by the purchaser. The preparation shall include that specified in 8.4.3.1 through 8.4.3.10.

8.4.3.1 Except for machined surfaces, all exterior surfaces that may corrode during shipment, storage, or in service, shall be given at least one coat of the manufacturer's standard paint, unless otherwise specified. The paint shall not contain lead or chromates.

NOTE Austenitic stainless steels are typically not painted.

8.4.3.2 Exterior machined surfaces except for corrosion-resistant material shall be coated with rust preventive.

8.4.3.3 The interior of the equipment shall be clean; free from scale, welding spatter and foreign objects; and, except for corrosion-resistant material, sprayed or flushed with rust preventive that can be removed with solvent. The rust preventive shall be applied through all openings while the shaft is rotated.

8.4.3.4 Internal surfaces of bearing housings and carbon steel oil system components shall be coated with epoxy or alternatively coated with oil-soluble rust preventive that is compatible with the lubricating oil.

8.4.3.5 Flanged openings shall be provided with metal closures at least 5 mm (0.19 in.) thick with elastomeric gaskets and at least four full-diameter bolts. For studded openings, all nuts needed for the intended service shall be used to secure closures.

8.4.3.6 Threaded openings shall be provided with steel caps or hex head steel plugs. In no case shall non-metallic (such as plastic) caps or plugs be used.

NOTE These are shipping plugs; permanent plugs are covered in 6.5.4.3.

8.4.3.7 Lifting points, lifting lugs and baseplate center of gravity shall be clearly identified on the equipment, equipment drawing, or equipment package. The recommended lifting arrangement shall be as described in the installation manual.

8.4.3.8 The equipment shall be identified with item and serial numbers. Material shipped separately shall be identified with securely affixed, corrosion-resistant metal tags indicating the item and serial number of the equipment for which it is intended. Crated equipment shall be shipped with duplicate packing lists, one inside and one on the outside of the shipping container.

8.4.3.9 Exposed shafts, and shaft couplings shall be protected with a corrosion barrier followed by a separate barrier material to protect against incidental mechanical damage.

8.4.3.10 Loose components shall be placed in plastic bags (or dipped in wax) and contained by cardboard boxes. Loose boxes are to be securely blocked in the shipping container.

8.4.4 Auxiliary piping connections supplied on the purchased equipment shall be impression-stamped or permanently tagged to agree with the vendor's connection table or general arrangement drawing. Service and connection designations shall be indicated.

8.4.5 Bearing assemblies shall be fully protected from the entry of moisture and dirt. If vapor-phase-inhibitor crystals in bags are installed in large cavities to absorb moisture, the bags must be attached in an accessible area for ease of removal. If applicable, bags shall be installed in wire cages attached to flanged covers and bag locations shall be indicated by corrosion-resistant tags attached with stainless steel wire.

8.4.6 One copy of the manufacturer's installation instructions shall be packed and shipped with the equipment.

8.4.7 Connections on auxiliary piping that are removed for shipment, shall be match marked for ease of reassembly.

● **8.4.8** If specified, the fit-up and assembly of machine-mounted piping, intercoolers etc. shall be completed in the vendor's shop prior to shipment.

9 Vendor's Data

9.1 General

9.1.1 The information to be furnished by the vendor is specified in 9.2 and 9.3.

9.1.2 The vendor's data shall be present on transmittal (cover) letters, title pages and in title blocks or other prominent position on drawings, and shall include the following information:

a) the purchaser's/owner's corporate name;

b) the job/project number;

c) the equipment item number and service name;

d) the inquiry or purchaser's order number;

e) any other identification specified in the inquiry or purchaser order;

f) the vendor's identifying proposal number, shop order number, serial number, or other reference required to completely identify return correspondence.

● **9.1.3** If specified, a coordination meeting shall be held, preferably at the vendor's plant, within four to six weeks after order commitment. Unless otherwise specified, the vendor shall prepare and distribute an agenda prior to this meeting, which as a minimum shall include a review of the following items:

a) the purchase order, scope of supply, unit responsibility, and subvendor items;

b) the datasheets;

c) applicable specifications and previously agreed-upon exceptions;

d) schedules for transmittal of data, production, and testing;

e) the quality assurance program and procedures;

f) inspection, expediting, and testing;

g) schematics and bills of material for auxiliary systems;

h) the physical orientation of the equipment, piping and auxiliary systems;

i) coupling selection and rating;

j) thrust and journal bearing sizing, estimated loadings and specific configurations;

k) rotor dynamic analyses (lateral, torsional and transient torsional, as required (commonly not available for 10 to 12 weeks after first drawing submittals);

l) equipment performance, alternative operating conditions, start-up, shutdown and any operating limitations;

m) scope and details of any pulsation or vibration analysis;

n) instrumentation and controls;

o) identification of items for stress analysis or other design reviews;

p) other technical items.

9.2 Proposals

9.2.1 General

9.2.1.1 The vendor shall forward the original proposal and the specified number of copies to the addressees specified in the inquiry documents. As a minimum, the proposal shall include the data specified in 9.2.2 through 9.2.5, as well as a specific statement that the system and all its components are in strict accordance with this standard. If the system and components are not in strict accordance, the vendor shall include a list that details and explains each deviation. The vendor shall provide details to enable the purchaser to evaluate any proposed alternative designs. All correspondence shall be clearly identified in accordance with 9.1.2.

9.2.2 Drawings

9.2.2.1 The drawings indicated on the VDDR form (see example in Annex D) shall be included in the proposal. As a minimum, the following data shall be furnished.

a) A general arrangement or outline drawing for each major skid or system, showing direction of rotation, size and location of major purchaser connections; overall dimensions; maintenance clearance dimensions; overall weights; erection weights; maximum maintenance weights (indicated for each piece), lifting points and methods of lifting the assembled machine.

b) Cross-sectional drawings showing the details of the proposed equipment.

c) Schematics of all auxiliary systems, including the seal flush, lubricating oil, control and electrical systems. Bills of material shall be included.

9.2.2.2 If typical drawings, schematics and bills of material are used, they shall be marked up to show the correct weight and dimension data and to reflect the actual equipment and scope proposed.

9.2.3 Technical Data

The following data shall be included in the proposal.

a) The purchaser’s datasheets, with complete vendor’s information entered thereon and literature to fully describe details of the offering.

b) The predicted noise data.

c) The VDDR form (see example in Annex D), indicating the schedule according to which the vendor agrees to transmit all the data specified as part of the purchase order.

d) A schedule for shipment of the equipment, in weeks after receipt of the order.

e) A list of major wearing components, showing interchangeability with other items on the project or the owner’s existing machines.

f) A list of spare parts recommended for start-up and normal maintenance purposes.

g) A list of the special tools furnished for maintenance.

h) A description of any special weather protection and winterization required for start-up, operation, and periods of idleness, under the site conditions specified on the datasheets. This description shall clearly indicate the protection to be furnished by the purchaser as well as that included in the vendor's scope of supply.

i) A complete tabulation of utility requirements, e.g. steam, water, electricity, air, gas, lubricating oil (including the quantity and supply pressure of the oil required, and the heat load to be removed by the oil), and the nameplate power rating and operating power requirements of auxiliary drivers. Approximate data shall be clearly indicated as such.

● j) A description of any optional or additional tests and inspection procedures for materials as required by 8.2.2.

k) A description of any special requirements whether specified in the purchaser's inquiry or as outlined in bulleted paragraphs of this specification.

● l) If specified, a list of similar machines installed and operating under similar conditions.

m) Any start-up, shutdown, or operating restrictions required to protect the integrity of the equipment.

n) Any test facility limitations.

o) A list of any components that can be construed as being of alternative design, hence requiring purchaser's acceptance.

9.2.4 Curves

The vendor shall provide complete performance curves, including differential pressure, efficiency, NPSHR/net positive inlet pressure required (NPIPR), and power expressed as functions of flow rate at the specified viscosity. Minimum flow (both thermal and stable), preferred and allowable operating regions, and any limitations of operation shall be indicated. For multiphase services the GVF must also be indicated.

9.2.5 Options

● If specified, the vendor shall furnish an outline of the procedures to be used for each of the special or optional tests that have been specified by the purchaser or proposed by the vendor.

9.3 Contract Data

9.3.1 General

9.3.1.1 Contract data shall be furnished by the vendor in accordance with the agreed VDDR form (see example in Annex D).

9.3.1.2 Each drawing shall have a title block in the lower right-hand corner with the date of certification, vendor's data specified in 9.1.2, revision number and date and title. Similar information shall be provided on all other documents.

9.3.1.3 The purchaser and vendor shall agree to the timing and extent of drawing and data review. Review by the purchaser does not constitute permission to deviate from any requirements in the order unless specifically agreed upon in writing.

9.3.1.4 A complete list of vendor data shall be included with the first issue of the major drawings. This list shall contain titles, drawing numbers, and a schedule for transmission of all the data the vendor will furnish (see example in Annex D).

9.3.2 Drawings and Technical Data

9.3.2.1 The drawings and data furnished by the vendor shall contain sufficient information so that, together with the manuals specified in 9.3.5, the purchaser can properly install, operate and maintain the equipment covered by the purchase order. Regardless of use of this standard's datasheets in the procurement process, a completed API 676 datasheet shall be included in the as-built data to document the pump. All contract drawings and data shall be clearly legible (8-point minimum font size even if reduced from a larger size drawing), shall cover the scope of the agreed VDDR form (see example in Annex D) and shall satisfy the applicable detailed descriptions. Dimensional outline drawings shall indicate the tolerance for pump suction and discharge nozzle face and centerline locations referenced from the centerline of the nearest baseplate anchor-bolt hole. The centerline of baseplate anchor-bolt hole locations shall indicate the tolerance from a common reference point on the baseplate.

9.3.2.2 Certified test curves and data shall be submitted within 15 days after testing and shall provide complete performance curves, including differential head (pressure), efficiency, NPSHR, and power expressed as functions of flow rate at the specified viscosity. The curve sheet shall include any identification number of the rotors, etc. and the pump serial number. If a NPSH test is specified, an NPSHR curve will also be provided.

9.3.3 Progress Reports

The vendor shall submit progress reports to the purchaser at the intervals specified on the VDDR form (see example in Annex D).

9.3.4 Parts Lists and Recommended Spares

9.3.4.1 The vendor shall submit complete parts lists for all equipment and accessories supplied. The lists shall include manufacturer's unique part numbers, materials of construction, and delivery times. Each part shall be completely identified and shown on cross-sectional or assembly-type drawings so that the purchaser may determine the interchangeability of these parts with other equipment. Parts that have been modified from standard dimensions and/or finish to satisfy specific performance requirements shall be uniquely identified by part number for interchangeability and future duplication purposes. Standard purchased items, including gaskets and O-rings, shall be identified by the original manufacturer's name, part number, material and pressure rating, if applicable.

9.3.4.2 The vendor shall indicate on each of these complete parts lists all those parts that are recommended as start-up or maintenance spares, and the recommended stocking quantities of each. These should include spare parts recommendations of sub-vendors that were not available for inclusion in the vendor's original proposal. The vendor shall forward the lists to the purchaser promptly after receipt of the reviewed drawings and in time to permit order and delivery of the parts before field start-up. The transmittal letter shall include the data specified in 9.1.2.

9.3.5 Data Manuals

9.3.5.1 General

The vendor shall provide sufficient written instructions and all necessary drawings to enable the purchaser to install, operate, and maintain all of the equipment covered by the purchase order. This information shall be compiled in a manual or manuals with a cover sheet showing the information listed in 9.1.2, an index sheet, and a complete list of the enclosed drawings by title and drawing number. The manual or manuals shall be prepared specifically for the equipment covered by the purchase order. Preprinted sections that are model specific may be included, but "typical" manuals are unacceptable. Vendor manuals shall also be furnished in an agreed upon electronic format that reflect the "as-supplied" equipment, with any safeguards considered necessary for legal protection of all parties.

9.3.5.2 Installation Manual

All information required for the proper installation of the equipment shall be compiled in a manual that shall be issued no later than the time of issue of final certified drawings. For this reason, it may be separate from the operating and maintenance instructions. This manual shall contain information on alignment and grouting procedures, normal and maximum utility requirements, centers of mass, rigging provisions and procedures, and all other installation data. All drawings and data specified in 9.2.2 and 9.2.3 that are pertinent to proper installation shall be included as part of this manual.

9.3.5.3 Manual for Operating, Maintenance and Technical Data

A manual containing operating, maintenance and technical data shall be sent at the time of shipment. In addition to covering operation at all specified process conditions, this manual shall include a section that provides special instructions for operation at specified extreme environmental conditions. The manual shall also include sketches that show the location of the centre of gravity and rigging provisions to permit the removal of the top half of the casings, rotors and any subassemblies having a mass greater than 135 kg (300 lb). As a minimum, the manual shall also include all of the data listed in Annex D that are not uniquely related to installation.

Annex A
(informative)

Rotary Pump Datasheets

DOCUMENT NUMBER:
CLIENT DOCUMENT NUMBER:

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

ROTARY PUMP (API 676-3RD)
DATA SHEET
SI UNITS (bar)

JOB NO. ______ ITEM NO. ______
PAGE 1 OF 3 REQ'N NO. ______

1 APPLICABLE TO: PROPOSAL PURCHASE AS BUILT PO NO. ______
2 FOR ______ UNIT ______
3 SITE ______ NO. OF PUMPS REQUIRED ______
4 SERVICE ______ SIZE AND TYPE ______
5 MANUFACTURER ______ SERIAL NO. ______
6
7 NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER ◙ BY MANUFACTURER OR PURCHASER
8 **GENERAL**
9 NO. MOTORS DRIVEN ______ OTHER DRIVER TYPE ______
10 PUMP ITEM NO'S ______ PUMP ITEM NO'S ______
11 MOTOR ITEM NO'S ______ DRIVER ITEM NO'S ______ GEAR ITEM NO'S ______
12 MOTOR PROVIDED BY ______ DRIVER PROVIDED BY ______ GEAR PROVIDED BY ______
13 MOTOR MOUNTED BY ______ DRIVER MOUNTED BY ______ GEAR MOUNTED BY ______
14 MOTOR DATA SHEET NO. ______ DRIVER DATA SHEET NO. ______ GEAR DATA SHEET NO. ______
15

16 ○ **OPERATING CONDITIONS**

17		MIN	NORMAL	RATED	MAX (1)
18	○ CAPACITY: (m³/h)				
19	○ OTHER OPER CONDITIONS: (m³/h)				
20	○ DISCHARGE PRESSURE: (barG)				
21	○ SUCTION PRESSURE : (barG)				
22	○ DIFFERENTIAL PRESSURE: (bar)				

23 ○ NPSH AVAILABLE ______ (m)
24 ○ NPIP AVAILABLE ______ (barA)
25 ○ NPSHAa / NPIP DATUM: ○ C.L. SUCTION NOZZLE
26 ○ TOP OF FOUNDATION
27 ○ DUTY CYCLE ○ CONTINUOUS ○ INTERMITTENT
28 (1) Maximum - mechanical design
29 ☐ **PERFORMANCE**
30 ☐ RATED CAPACITY (m³/h) ______
31 ☐ NPSHa / NPIP REQUIRED (m) ______ (barA) ______
32 ☐ RATED SPEED (rpm) ______
33 ☐ RATED VOLUMETRIC EFFICIENCY (%) ______
34 ☐ RATED PUMP EFFICIENCY (%) ______
35 ☐ REQUIRED POWER @ MAXIMUM VISCOSITY (BkW) ______
36 ☐ REQUIRED POWER @ PRESSURE LIMITING VAL (BkW) ______
37 ☐ REQUIRED POWER @ RATED CONDITION (BkW) ______
38 ☐ MAXIMUM ALLOWABLE SPEED (rpm)
39
40
41 ☐ **CONSTRUCTION**

42		SIZE	ANSI RATING	FACING	POSITION
43	CONNECTIONS				
44	SUCTION				
45	DISCHARGE				
46	GLAND FLUSH				
47	DRAINS *				
48	VENTS *				
49	JACKET				

50 * PIPE VENTS & DRAINS TO EDGE OF BASEPLATE
51 ☐ **PUMP TYPE**
52 ◙ INTERNAL GEAR ◙ TWIN-SCREW ◙ VANE ○ LOBE
53 ◙ EXTERNAL GEAR ◙ 3-SCREW ◙ PROGRESSING CAVITY
54 ◙ ROTARY GEAR TYPE
55
56
57
58 REMARKS: ______
59 ______
60 ______
61

○ **PUMPED FLUID**

○ TYPE OR NAME OF PUMPED FLUID ______

	MIN	NORMAL	RATED
○ TEMPERATURE: (°C)			
○ VAPOR PRESS.: (barA)			
○ RELATIVE DENSITY (SG):			
○ VISCOSITY: (mPa-s)			

○ SPECIFIC HEAT ______ Cp (kJ/kg °C)
○ CORROSIVE/EROSIVE AGENTS DESCRIPTION
○ EROSIVE ______ ○ CORROSIVE
○ CHLORIDE CONCENTRATION (ppm) ______
○ H_2S CONCENTRATION (ppm) ______
FLUID ○ HAZARDOUS ○ FLAMMABLE ○ OTHER ______
○ GAS ○ ENTRAINED ○ SLUG FLOW % BY VOLUME or GVF ______
○ SOLIDS PARTICLE SIZE DISTRIBUTION & MIN/MAX ______ (μ)
○ SHAPE ______ ○ CONCENTRATION ______ ○ HARDNESS ______

○ **SITE AND UTILITY DATA**

LOCATION ○ INDOOR ○ OUTDOOR
○ HEATED ○ UNHEATED ○ UNDER ROOF
○ ELECTRICAL AREA CLASS ______ GROUP ______ DIV ______
ZONE ______ GROUP ______ TEMP CLASS ______
○ WINTERIZATION REQD ○ TROPICALIZATION REQD
SITE DATA ○ ELEVATION ______ (°C) ○ BAROMETER ______ (barA)
○ RANGE OF AMBIENT TEMPS:MIN/MAX ______ / ______ (°C)
UNUSUAL CONDITIONS
○ DUST ○ FUMES ○ SALT ATMOSPHERE
○ OTHER ______
○ UTILITY CONDITIONS

ELECTRICITY	DRIVERS	HEATING	CONTROL	SHUTDOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER	INLET	RETURN	DESIGN	MAX Δ
TEMP (°C)		MAX		
PRESS. (barG)		MIN		
SOURCE				

INSTRUMENT AIR MAX MIN
PRESSURE (barG) ______ ______

APPLICABLE SPECIFICATIONS:

API-676 POSITIVE DISPLACEMENT PUMPS - ROTARY
○ GOVERNING SPECIFICATION (IF DIFFERENT) ______
○ NACE MR0103 (6.13.2.13) ○ NACE MR0175
○ OTHER ______

DOCUMENT NUMBER:
CLIENT DOCUMENT NUMBER:

REVISION	0	1	2	3	4
DATE					
BY					
REV/APPR					

JOB NO. ITEM NO.
PAGE 2 OF 3 REQ'N NO.

ROTARY PUMP (API 676-3RD)
DATA SHEET
SI UNITS (bar)

CONSTRUCTION

CASING
- ☐ MAX. ALLOWABLE CASING PRESS. (6.3.1): (barG) @ (°C)
- ☐ MAXIMUM ALLOWABLE SUCTION PRESSURE: (barG) @ (°C)
- ☐ HYDROSTATIC TEST PRESSURE - Suct / Disch: / (barG)

ROTATING ELEMENTS
- ROTOR MOUNT ☐ BTWN. BEARINGS ☐ OVERHUNG
- TIMING GEARS ☐ YES ☐ NO ☐ TYPE
- BEARING TYPE: ☐ RADIAL ☐ THRUST
- BEARING NUMBER: ☐ RADIAL ☐ THRUST
- LUBRICATION TYPE: ○ CONSTANT LEVEL OILERS
- ○ PUMPED FLUID ◙ RING OIL ◙ OIL MIST
- ○ EXTERNAL ○ OIL FLOOD ○ GREASE
- ☐ LUBRICANT Info (Visc, etc)
- ○ **MECHANICAL SEALS**
  - ☐ MANUFACTURER AND MODEL
  - ☐ MANUFACTURER CODE
  - ○ API 682 AND DATA SHEETS
- ○ API 682 SEAL FLUSH PLAN
- ☐ API 682 SEAL CODE

DRIVER TYPE

○ INDUCTION MOTOR ○ STEAM TURBINE ○ GEAR ○ OTHER

DRIVE MECHANISM

- ○ DIRECT-COUPLED ○ ASD ○ OTHER
- ◙ COUPLING MANUFACTURER
- ◙ COUPLING TYPE
- ☐ RATING (MAX TORQUE) ◙ MODEL
- ◙ SPACER LENGTH (IN) ◙ S.F.
- ○ COUPLING BALANCED ○ MANF STD ○ AGMA 9000 CLASS 10 (7.2.3)
- ○ COUPLING PER API 671 (7.2.4)
- ○ COUPLING HUB ATTACHMENT
  - ○ STRAIGHT ○ KEYED ○ TAPERED

COUPLING GUARD TYPE
- ○ STEEL ○ BRASS ○ NON-METALLIC ○ OTHER
- ◙ NON SPARK COUPLING GUARD (7.2.15)

○ MOTOR DRIVER (SEE MOTOR DATA SHEET)

- ○ IEEE 841 ○ API 541 ○ API 546 ○ OTHER
- ○ ASD SUPPLIED BY ○ PURCHASER ○ MOTOR SUPPLIER
- ☐ MANUFACTURER ☐ TYPE
- ☐ FRAME ◙ ENCLOSURE
- ◙ HORIZONTAL ◙ VERTICAL
- ☐ (kW) (rpm)
- ○ VOLTS PHASE HERTZ SERVICE FACTOR
- ○ VARIABLE SPEED RANGE (rpm)
- ○ MINIMUM STARTING VOLTAGE (7.1.2.2)
- ◙ INSULATION ○ TEMP. RISE
- ◙ FULL LOAD AMPS
- ◙ LOCKED ROTOR AMPS
- ◙ STARTING METHOD
- ◙ LUBE

BEARINGS (TYPE/NUMBER):
- ☐ RADIAL /
- ☐ THRUST /

MATERIALS

- ○ MIN DESIGN METAL TEMP (6.13.6.1) (°C)
- ☐ CASING
- ☐ STATOR / LINER
- ☐ END PLATES
- ☐ ROTOR (S)
- ☐ VANES
- ☐ SHAFT
- ☐ SLEEVE (S)
- ☐ GLAND (S)
- ☐ BEARING HOUSING
- ☐ TIMING GEARS
- ☐ ELASTOMERS / GASKETS

QA INSPECTION AND TEST

- ○ SPECIAL MATERIAL TESTS (See design codes + weld + inspection sheet)
- ○ LOW AMBIENT TEMP. MATERIALS TESTS (6.13.6.5)
- ○ COMPLIANCE WITH INSPECTORS CHECK LIST
- ○ CERTIFICATION OF MATERIALS (user to define affected components in remarks)
- ○ SURFACE / SUBSURFACE EXAM'S (user to define affected components in remarks)
  - ○ RADIOGRAPHY
  - ○ ULTRASONIC
  - ○ MAGNETIC PARTICLE
  - ○ LIQUID PENETRANT
  - ○ COMPONENT PMI
- ○ HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES
- ○ VENDOR SUBMIT TEST PROCEDURES (8.3.1.2)
- ○ SUPPLIER TO KEEP REPAIR AND HT RECORDS (8.2.1.1)

	NON-WIT	WIT	OBSERV
○ SHOP INSPECTION (8.1)	○	○	○
○ HYDROSTATIC (8.3.2)	○	○	○
WITH WETTING AGENT	○	○	○
○ PERFORMANCE (8.3.4)	○	○	○
○ RETEST ON SEAL LEAKAGE	○	○	○
○ NPSH / NPIP (8.3.7.1)	○	○	○
○ TRUE PEAK VELOCITY DATA	○	○	○
○ COMPLETE UNIT TEST (8.3.7.2)	○	○	○
○ SOUND LEVEL TEST (8.3.7.3)	○	○	○
○ CLEANLINESS PRIOR TO FINAL ASSEMBLY (8.2.3.3)	○	○	○
○ HIGH DISCHARGE PRESSURE @ PLV	○	○	○
○ CHECK FOR CO-PLANAR AT MOUNTING PAD SURFACES (7.4.7)	○	○	○
○ 1 HR MECHANICAL RUN TEST AFTER OIL TEMP STABLE (8.3.5.1)	○	○	○
○ 4 HR. MECH RUN AFTER OIL TEMP STABLE(8.3.5.2)	○	○	○
○ AUXILIARY EQUIPMENT TEST (8.3.4.3)	○	○	○
○ OTHER	○	○	○

- ○ TEST WITH SUBSTITUTE SEAL (8.3.5.3)
- ○ SUPPLIER SUBMIT TEST DATA WITHIN 24 HOURS
- ○ INCLUDE PLOTTED VIBRATION SPECTRA
- ○ RECORD FINAL ASSEMBLY RUNNING CLEARANCES (8.2.1.1f)
- ○ PERFORMANCE CURVE & DATA APPROVAL PRIOR TO SHIPMENT (8.3.9)

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ROTARY PUMP (API 676-3RD)
DATA SHEET
SI UNITS (bar)

PIPING & APPURTENANCES

MANIFOLD PIPING FOR PURCHASER CONNECTION
VENT DRAIN STEAM / COOLING WATER
HEATING JACKET REQ'D. (6.3.6) COOLING REQ'D
PIPE TUBING; FITTINGS
C.S. GALVANIZED S. STEEL
VALVES: CARBON STEEL S. STEEL
FLANGES REQUIRED IN PLACE OF SOCKET WELD UNIONS
MOUNT SEAL POT OFF BASEPLATE
CONNECTION BOLTING CADMIUM PLATED BOLTS PROHIBITED
PTFE COATING ASTM A153 GALVANIZED
PAINTED SS

HEATING AND COOLING

HEATING MEDIUM: STEAM OTHER
STEAM JACKET/COOLING WATER PRES: (barG) @ (°C)
COOLING WATER REQUIREMENTS:
BEARING HOUSING (m^3/h) @ (barG)
LUBE OIL COOLER (m^3/h) @ (barG)
SEAL OIL COOLER (m^3/h) @ (barG)
OTHER (m^3/h) @ (barG)
TOTAL COOLING WATER (m^3/h) @ (barG)

INSTRUMENTATION

ACCELEROMETER
PROVISION FOR MTG ONLY
FLAT SURFACE REQUIRED
RADIAL BEARING TEMP. THRUST BEARING TEMP.
TEMP. GAUGES (WITH THERMOWELLS)
PRESSURE GAUGE TYPE OTHER

REMARKS:

PREPARATION FOR SHIPMENT

DOMESTIC EXPORT EXPORT BOXING REQ'D
OUTDOOR STORAGE MORE THAN 6 MONTHS

SURFACE PREPARATION AND PAINT

MANUFACTURER'S STANDARD OTHER (SEE BELOW)
SPECIFICATION NO.
PUMP: (8.4.3.1)
PRIMER
FINISH COAT
BASEPLATE: (8.4.3.1)
PRIMER
FINISH COAT

WEIGHTS (kg)

PUMP BASE GEAR DRIVER
TOTAL WEIGHT

BASEPLATE

BY PUMP MANUFACTURER SUITABLE FOR EPOXY GROUT
EXTENDED FOR
DRAIN-RIM DRAIN-PAN
NON-GROUT CONSTRUCTION (7.4.2)

OTHER PURCHASER REQUIREMENTS

NAMEPLATE UNITS U.S. CUSTOMARY SI
RELIEF VALVES BY PUMP MFRG INTERNAL EXTRNL.
PIPING FOR SEAL FLUSH FURNISHED BY:
PUMP VENDOR OTHERS
PIPING FOR COOLING/HEATING FURNISHED BY:
PUMP VENDOR OTHERS
PROVIDE TECHNICAL DATA MANUAL
INSTALLATION LIST IN PROPOSAL (9.2.3.I)

REMARKS:

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CLIENT DOCUMENT NUMBER:

ROTARY PUMP (API 676-3RD)
DATA SHEET
U.S. CUSTOMARY

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APPLICABLE TO: ☐ PROPOSAL ☐ PURCHASE ☐ AS BUILT PO NO.
FOR UNIT
SITE NO. OF PUMPS REQUIRED
SERVICE SIZE AND TYPE
MANUFACTURER SERIAL NO.

NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER ☐ BY MANUFACTURER OR PURCHASER

GENERAL

NO. MOTORS DRIVEN OTHER DRIVER TYPE
PUMP ITEM NO'S PUMP ITEM NO'S
MOTOR ITEM NO'S DRIVER ITEM NO'S GEAR ITEM NO'S
MOTOR PROVIDED BY DRIVER PROVIDED BY GEAR PROVIDED BY
MOTOR MOUNTED BY DRIVER MOUNTED BY GEAR MOUNTED BY
MOTOR DATA SHEET NO. DRIVER DATA SHEET NO. GEAR DATA SHEET NO.

○ OPERATING CONDITIONS

	MIN	NORMAL	RATED	MAX (1)
○ CAPACITY: (gpm)				
○ OTHER OPER CONDITIONS: (gpm)				
○ DISCHARGE PRESSURE: (psig)				
○ SUCTION PRESSURE : (psig)				
○ DIFFERENTIAL PRESSURE: (psi)				

○ NPSH AVAILABLE (ft)
○ NPIP AVAILABLE (psia)
○ NPSHa / NPIP DATUM: ○ C.L. SUCTION NOZZLE
○ TOP OF FOUNDATION
○ DUTY CYCLE ○ CONTINUOUS ○ INTERMITTENT
(1) Maximum - mechanical design

☐ PERFORMANCE

☐ RATED CAPACITY (gpm)
☐ NPSHa / NPIP REQUIRED (ft) (psia)
☐ RATED SPEED (rpm)
☐ RATED VOLUMETRIC EFFICIENCY (%)
☐ RATED PUMP EFFICIENCY (%)
☐ REQUIRED POWER @ MAXIMUM VISCOSITY (BHP)
☐ REQUIRED POWER @ PRESSURE LIMITING VAL (BHP)
☐ REQUIRED POWER @ RATED CONDITION (BHP)
☐ MAXIMUM ALLOWABLE SPEED (rpm)

☐ CONSTRUCTION

CONNECTIONS	SIZE	ANSI RATING	FACING	POSITION
SUCTION				
DISCHARGE				
GLAND FLUSH				
DRAINS *				
VENTS *				
JACKET				

* PIPE VENTS & DRAINS TO EDGE OF BASEPLATE

☐ PUMP TYPE

☐ INTERNAL GEAR ☐ TWIN-SCREW ☐ VANE ○ LOBE
☐ EXTERNAL GEAR ☐ 3-SCREW ☐ PROGRESSING CAVITY
☐ ROTARY GEAR TYPE

○ PUMPED FLUID

○ TYPE OR NAME OF PUMPED FLUID

	MIN	NORMAL	RATED
○ TEMPERATURE: (°F)			
○ VAPOR PRESS.: (psia)			
○ RELATIVE DENSITY (SG):			
○ VISCOSITY: (cP)			

○ SPECIFIC HEAT Cp (BTU/lb °F)
○ CORROSIVE/EROSIVE AGENTS DESCRIPTION
○ EROSIVE ○ CORROSIVE
○ CHLORIDE CONCENTRATION (ppm)
○ H_2S CONCENTRATION (ppm)
FLUID ○ HAZARDOUS ○ FLAMMABLE ○ OTHER
○ GAS ○ ENTRAINED ○ SLUG FLOW % BY VOLUME or GVF
○ SOLIDS PARTICLE SIZE DISTRIBUTION & MIN/MAX (μ)
○ SHAPE ○ CONCENTRATION ○ HARDNESS

○ SITE AND UTILITY DATA

LOCATION ○ INDOOR ○ OUTDOOR
○ HEATED ○ UNHEATED ○ UNDER ROOF
○ ELECTRICAL AREA CLASS GROUP DIV
ZONE GROUP TEMP CLASS
○ WINTERIZATION REQD ○ TROPICALIZATION REQD
SITE DATA ○ ELEVATION (°F) ○ BAROMETER (psia)
○ RANGE OF AMBIENT TEMPS:MIN/MAX / (°F)
UNUSUAL CONDITIONS
○ DUST ○ FUMES ○ SALT ATMOSPHERE
○ OTHER
○ UTILITY CONDITIONS

ELECTRICITY	DRIVERS	HEATING	CONTROL	SHUTDOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER	INLET	RETURN	DESIGN	MAX Δ
TEMP (°F)	MAX			
PRESS. (psig)	MIN			
SOURCE				

INSTRUMENT AIR MAX MIN
PRESSURE (psig)

APPLICABLE SPECIFICATIONS:

API-676 POSITIVE DISPLACEMENT PUMPS - ROTARY
○ GOVERNING SPECIFICATION (IF DIFFERENT)
○ NACE MR0103 (6.13.2.13) ○ NACE MR0175
○ OTHER

REMARKS:

DOCUMENT NUMBER:

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ROTARY PUMP (API 676-3RD)
DATA SHEET
U.S. CUSTOMARY

JOB NO. ITEM NO.

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1	**CONSTRUCTION**	**MATERIALS**
2	**CASING**	MIN DESIGN METAL TEMP (6.13.6.1) (°F)
3	MAX. ALLOWABLE CASING PRESS. (6.3.1): (psig) @ (°F)	CASING
4	MAXIMUM ALLOWABLE SUCTION PRESSURE: (psig) @ (°F)	STATOR / LINER
5	HYDROSTATIC TEST PRESSURE - Suct / Disch: / (psig)	END PLATES
6	**ROTATING ELEMENTS**	ROTOR (S)
7	ROTOR MOUNT BTWN. BEARINGS OVERHUNG	VANES
8	TIMING GEARS YES NO TYPE	SHAFT
9	BEARING TYPE: RADIAL THRUST	SLEEVE (S)
10	BEARING NUMBER: RADIAL THRUST	GLAND (S)
11	LUBRICATION TYPE: CONSTANT LEVEL OILERS	BEARING HOUSING
12	PUMPED FLUID RING OIL OIL MIST	TIMING GEARS
13	EXTERNAL OIL FLOOD GREASE	ELASTOMERS / GASKETS
14	LUBRICANT Info (Visc, etc)	
15	**MECHANICAL SEALS**	**QA INSPECTION AND TEST**
16	MANUFACTURER AND MODEL	SPECIAL MATERIAL TESTS (See design codes + weld + inspection sheet)
17	MANUFACTURER CODE	LOW AMBIENT TEMP. MATERIALS TESTS (6.13.6.5)
18	API 682 AND DATA SHEETS	COMPLIANCE WITH INSPECTORS CHECK LIST
19	API 682 SEAL FLUSH PLAN	CERTIFICATION OF MATERIALS (user to define affected components in remarks)
20	API 682 SEAL CODE	SURFACE / SUBSURFACE EXAM'S (user to define affected components in remarks)
21		RADIOGRAPHY
22	**DRIVER TYPE**	ULTRASONIC
23	INDUCTION MOTOR STEAM TURBINE GEAR OTHER	MAGNETIC PARTICLE
24	**DRIVE MECHANISM**	LIQUID PENETRANT
25	DIRECT-COUPLED ASD OTHER	COMPONENT PMI
26	COUPLING MANUFACTURER	HARDNESS OF PARTS, WELDS & HEAT AFFECTED ZONES
27	COUPLING TYPE	VENDOR SUBMIT TEST PROCEDURES (8.3.1.2)
28	RATING (MAX TORQUE) MODEL	SUPPLIER TO KEEP REPAIR AND HT RECORDS (8.2.1.1)
29	SPACER LENGTH (IN) S.F.	NON-WIT WIT OBSERV
30	COUPLING BALANCED MANF STD AGMA 9000 CLASS 10 (7.2.3)	SHOP INSPECTION (8.1)
31	COUPLING PER API 671 (7.2.4)	HYDROSTATIC (8.3.2)
32	COUPLING HUB ATTACHMENT	WITH WETTING AGENT
33	STRAIGHT KEYED TAPERED	PERFORMANCE (8.3.4)
34	**COUPLING GUARD TYPE**	RETEST ON SEAL LEAKAGE
35	STEEL BRASS NON-METALLIC OTHER	NPSH / NPIP (8.3.7.1)
36	NON SPARK COUPLING GUARD (7.2.15)	TRUE PEAK VELOCITY DATA
37		COMPLETE UNIT TEST (8.3.7.2)
38	**MOTOR DRIVER (SEE MOTOR DATA SHEET)**	SOUND LEVEL TEST (8.3.7.3)
39	IEEE 841 API 541 API 546 OTHER	CLEANLINESS PRIOR TO
40	ASD SUPPLIED BY PURCHASER MOTOR SUPPLIER	FINAL ASSEMBLY (8.2.3.3)
41	MANUFACTURER TYPE	HIGH DISCHARGE PRESSURE @ PLV
42	FRAME ENCLOSURE	CHECK FOR CO-PLANAR AT
43	HORIZONTAL VERTICAL	MOUNTING PAD SURFACES (7.4.7)
44	(HP) (rpm)	1 HR MECHANICAL RUN TEST AFTER
45	VOLTS PHASE HERTZ SERVICE FACTOR	OIL TEMP STABLE (8.3.5.1)
46	VARIABLE SPEED RANGE (rpm)	4 HR. MECH RUN AFTER
47	MINIMUM STARTING VOLTAGE (7.1.2.2)	OIL TEMP STABLE(8.3.5.2)
48	INSULATION TEMP. RISE	AUXILIARY EQUIPMENT TEST (8.3.4.3)
49	FULL LOAD AMPS	OTHER
50	LOCKED ROTOR AMPS	TEST WITH SUBSTITUTE SEAL (8.3.5.3)
51	STARTING METHOD	SUPPLIER SUBMIT TEST DATA WITHIN 24 HOURS
52	LUBE	INCLUDE PLOTTED VIBRATION SPECTRA
53	BEARINGS (TYPE/NUMBER):	RECORD FINAL ASSEMBLY RUNNING CLEARANCES (8.2.1.1f)
54	RADIAL /	PERFORMANCE CURVE & DATA APPROVAL PRIOR TO SHIPMENT (8.3.9)
55	THRUST /	
56		
57		

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ROTARY PUMP (API 676-3RD)
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PIPING & APPURTENANCES

MANIFOLD PIPING FOR PURCHASER CONNECTION

- VENT
- DRAIN
- STEAM / COOLING WATER

HEATING JACKET REQ'D. (6.3.6) — COOLING REQ'D

PIPE — TUBING; — FITTINGS ______

C.S. — GALVANIZED — S. STEEL

VALVES: CARBON STEEL — S. STEEL

FLANGES REQUIRED IN PLACE OF SOCKET WELD UNIONS

MOUNT SEAL POT OFF BASEPLATE

CONNECTION BOLTING — CADMIUM PLATED BOLTS PROHIBITED

PTFE COATING — ASTM A153 GALVANIZED

PAINTED — SS

HEATING AND COOLING

HEATING MEDIUM: STEAM — OTHER

STEAM JACKET/COOLING WATER PRES: ______ (psig) @ ______ (°F)

COOLING WATER REQUIREMENTS:

BEARING HOUSING	______	(gpm)	@	______	(psig)
LUBE OIL COOLER	______	(gpm)	@	______	(psig)
SEAL OIL COOLER	______	(gpm)	@	______	(psig)
OTHER ______	______	(gpm)	@	______	(psig)
TOTAL COOLING WATER		(gpm)	@		(psig)

INSTRUMENTATION

ACCELEROMETER ______

PROVISION FOR MTG ONLY

FLAT SURFACE REQUIRED

RADIAL BEARING TEMP. — THRUST BEARING TEMP.

TEMP. GAUGES (WITH THERMOWELLS) ______

PRESSURE GAUGE TYPE ______ — OTHER ______

REMARKS:

PREPARATION FOR SHIPMENT

DOMESTIC — EXPORT — EXPORT BOXING REQ'D

OUTDOOR STORAGE MORE THAN 6 MONTHS

SURFACE PREPARATION AND PAINT

MANUFACTURER'S STANDARD — OTHER (SEE BELOW)

SPECIFICATION NO. ______

PUMP: (8.4.3.1)

PRIMER ______

FINISH COAT ______

BASEPLATE: (8.4.3.1)

PRIMER ______

FINISH COAT ______

WEIGHTS (lb)

PUMP ______ BASE ______ GEAR ______ DRIVER ______

TOTAL WEIGHT ______

BASEPLATE

BY PUMP MANUFACTURER — SUITABLE FOR EPOXY GROUT

EXTENDED FOR ______

DRAIN-RIM — DRAIN-PAN

NON-GROUT CONSTRUCTION (7.4.2)

OTHER PURCHASER REQUIREMENTS

NAMEPLATE UNITS — U.S. CUSTOMARY — SI

RELIEF VALVES BY PUMP MFRG — INTERNAL — EXTRNL.

PIPING FOR SEAL FLUSH FURNISHED BY:

PUMP VENDOR — OTHERS

PIPING FOR COOLING/HEATING FURNISHED BY:

PUMP VENDOR — OTHERS

PROVIDE TECHNICAL DATA MANUAL

INSTALLATION LIST IN PROPOSAL (9.2.3.l)

REMARKS:

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MULTIPHASE
PUMP DATA SHEET (API 676 3rd Ed.)
SI UNITS (bar)

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APPLICABLE TO: PROPOSAL PURCHASE AS BUILT

FOR UNIT
SITE SERIAL NO.
SERVICE NO. REQUIRED
MANUFACTURER MODEL DRIVER
NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER ◯ BY MANUFACTURER OR PURCHASER

OPERATING CONDITIONS

		MIN	NORMAL	RATED	MAX (1)
○ CAPACITY:	(BPD)				
○ OTHER CAPACITY:	(m^3/h)				
○ SUCTION PRESSURE :	(barG)				
○ DISCHARGE PRESSURE:	(barG)				
○ DIFFERENTIAL PRESSURE	(bar)				

○ DUTY CYCLE ○ CONTINUOUS ○ INTERMITTENT

(1) Maximum - mechanical design

PUMPED FLUID

○ TYPE OR NAME OF PUMPED FLUID

	MIN	NORMAL	RATED
○ TEMPERATURE: (°C)			
○ VAPOR PRESS.: (barA)			
○ RELATIVE DENSITY (SG):			
○ VISCOSITY: (mPa-s)			

○ SPECIFIC HEAT Cp (kJ/kg °C)
○ CORROSIVE/EROSIVE AGENTS
○ CHLORIDE CONCENTRATION (ppm)
○ H_2S CONCENTRATION (ppm)
FLUID ○ HAZARDOUS ○ FLAMMABLE ○ OTHER
○ EROSIVE ○ CORROSIVE

MULTIPHASE CONDITIONS

○ GAS DESCRIPTION (SEE GAS ANALYSIS)
○ SETTLE OUT PRESSURE (barA)
○ GAS VOLUME or GVF % MIN MAX
○ ENTRAINED ○ SLUG FLOW ○ OTHER
○ SOLIDS PARTICLE SIZE DISTRIBUTION & MIN/MAX (μ)
○ CONCENTRATION ○ HARDNESS
○ SHAPE

PERFORMANCE

☐ RATED CAPACITY (m^3/h)
☐ RATED SPEED (rpm)
☐ RATED VOLUMETRIC EFFICIENCY (%)
☐ RATED PUMP EFFICIENCY (%)
☐ REQUIRED POWER @ MAXIMUM VISCOSITY (BkW)
☐ REQUIRED POWER @ PRESSURE LIMITING (BkW)
☐ REQUIRED POWER @ RATED CONDITION (BkW)
☐ MAXIMUM ALLOWABLE SPEED (rpm)

REMARKS:

GAS ANALYSIS

GAS ANALYSIS ○ MOL % ○	M.W.	NOR-MAL	MAX-IMUM	REMARKS
AIR	28.966			
OXYGEN	32.000			
NITROGEN	28.016			
WATER VAPOR	18.016			
CARBON MONOXIDE	28.010			
CARBON DIOXIDE	44.010			
HYDROGEN SULFIDE	34.076			
HYDROGEN	2.016			
METHANE	16.042			
ETHYLENE	28.052			
ETHANE	30.068			
PROPYLENE	42.078			
PROPANE	44.094			
I-BUTANE	58.120			
n-BUTANE	58.120			
I-PENTANE	72.146			
n-PENTANE	72.146			
HEXANE PLUS				
TOTAL				
AVG. MOL. WT.				

SUPPLIER WITH UNIT RESPONSIBILITY
○ PUMP MANUFACTURER ○ OTHER

APPLICABLE SPECIFICATIONS:
API 676 POSITIVE DISPLACEMENT ROTARY PUMPS
○ GOVERNING SPECIFICATION (IF DIFFERENT)
○ MOTOR (See Page 6)
○ NACE MR0103 (6.13.2.13) ○ NACE MR0175
○ NOISE SOUND LEVEL dB @

LUBE AND SEAL OIL CIRCULATION SYSTEMS (API 614 chapter 3)
○ LUBE SYSTEM ○ SEAL OIL SYSTEMS (plan 54) ○ OTHER

PAINTING: (8.4.3.1)
○ MANUFACTURER'S STD. ○ OTHER

PREPARE FOR SHIPMENT: (8.4)
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D
○ LONG TERM STORAGE FOR MONTHS

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MULTIPHASE
PUMP DATA SHEET (API 676 3rd Ed.)
SI UNITS (bar)

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1 **LOCATION:**
2 ○ INDOOR ○ HEATED ○ UNDER ROOF
3 ○ OUTDOOR ○ UNHEATED ○ PARTIAL SIDES
3 ○ GRADE ○ MEZZANINE ○ ______
4 ○ ELECTRICAL AREA CLASS ○ NON-HAZARDOUS
5 CL ______ GR ______ DIV. ______ TEMP CLASS ______
6 ZONE ______ CLASS ______ GROUP ______
7 ○ WINTERIZATION REQ'D. ○ TROPICALIZATION REQ'D.
8 **SITE DATA:**
9 ○ ELEVATION ______ (m) BAROMETER ______ (barA)
10 ○ RANGE OF AMBIENT TEMPS.:

11			DRY BULB	WET BULB
12	SITE RATED	(°C)		
13	NORMAL	(°C)		
14	MAXIMUM	(°C)		
15	MINIMUM	(°C)		

16 **UNUSUAL CONDITIONS:**
17 ○ DUST ○ FUMES ○ SALT ATMOSPHERE
18 ○ OTHER ______
19

20 **UTILITY CONDITIONS:**

21	STEAM		DRIVERS		HEATING	
22	INLET	MIN.	(barG)	(°C)	(barG)	(°C)
23		NORM	(barG)	(°C)	(barG)	(°C)
24		MAX.	(barG)	(°C)	(barG)	(°C)
25	EXHAUST	MIN.	(barG)	(°C)	(barG)	(°C)
26		NORM	(barG)	(°C)	(barG)	(°C)
27		MAX.	(barG)	(°C)	(barG)	(°C)

28 **ELECTRICITY:**

29		DRIVERS	HEATING	CONTROL	SHUT-DOWN
30	VOLTAGE				
31	HERTZ				
32	PHASE				

33 **COOLING WATER**
34 TEMP. INLET ______ (°C) MAX. RETURN ______ (°C)
35 PRESS. NORM ______ (barG) DESIGN ______ (barG)
36 MIN. RETURN ______ (barG) MAX. ALLOW D P ______ (barA)
37 WATER SOURCE ______
38 **INSTRUMENT AIR:**
39 MAX PRESS ______ (barG) MIN. ______ (barG)
40 ☐ **TOTAL UTILITY CONSUMPTION:**
41 COOLING WATER ______ (L/min)
42 STEAM, NORMAL ______ (kg/h)
43 STEAM, MAX ______ (kg/h)
44 INSTRUMENT AIR ______ (m^3/h)
45 POWER (DRIVER) ______ (kW)
46 POWER (AUXILIARIES): ______ (kW)
47
48 **BASEPLATE (7.4)**
49 ○ COMMON (UNDER PUMP & DRIVER) ○ OTHER ______
50 ○ DECKED WITH NON-SKID DECK PLATE (7.4.12) ○ OPEN CONSTR.
51 ○ DRIP RIM ○ WITH OPEN DRAIN ○ SUBPLATE
52 ○ HORIZONTAL ADJUSTING SCREWS FOR EQUIPMENT (7.4.4)
53 ○ EPOXY GROUT/EPOXY PRIMER
54 **REMARKS** ______
55

☐ **CONNECTIONS:**

	SIZE	ANSI RATING	FACING	POSI-TION
CASING (4.3)				
INLET				
DISCHARGE				
SKID INLET				
SKID OUTLET				

☐ **OTHER CONNECTIONS:**

SERVICE:	NO	SIZE	TYPE / ANSI RATING
LUBE OIL OUTLET			
SEAL OIL INLET			
SEAL OIL OUTLET			
CASING DRAINS			
VENTS			
COOLING WATER			
CASE PRESSURE			
TEMPERATURE			
PURGE FOR: ______			

DRIVER TYPE

○ INDUCTION MOTOR ○ STEAM TURBINE ○ GEAR ○ OTHER

DRIVE MECHANISM

○ DIRECT-COUPLED ○ ASD ○ OTHER ______
☐ COUPLING MANUFACTURER ______
☐ COUPLING TYPE ______
☐ RATING (MAX TORQUE) ______ ☐ MODEL ______
☐ SPACER LENGTH ______ (IN) ☐ S.F. ______
○ COUPLING BALANCED ○ MANF STD ○ ISO 1940-1 G6.3 (7.2.3)
○ COUPLING PER API 671 (7.2.4)
○ COUPLING HUB ATTACHMENT ○ TAPERED
○ STRAIGHT ○ KEYED ○ HYRDRAULIC FIT

COUPLING GUARD TYPE

○ STEEL ○ BRASS ○ NON-METALLIC ○ OTHER
☐ NON SPARK COUPLING GUARD (7.2.15c) ______

○ MOTOR DRIVER (7.1) (SEE MOTOR DATA SHEET)

○ IEEE 841 ○ API 541 ○ API 546 ○ OTHER
○ ASD SUPPLIED BY ○ PURCHASER ○ MOTOR SUPPLIER
☐ MANUFACTURER ______ ☐ TYPE ______
☐ FRAME ______ ☐ ENCLOSURE ______
☐ HORIZONTAL ☐ VERTICAL
☐ (kW) ______ (rpm) ______
○ VOLTS ______ PHASE ______ HERTZ ______ SERVICE FACTOR ______
○ VARIABLE SPEED RANGE ______ (rpm)
○ MINIMUM STARTING VOLTAGE (7.1.2.2) ______
☐ INSULATION ______ ○ TEMP. RISE ______
☐ FULL LOAD AMPS ______
☐ LOCKED ROTOR AMPS ______
☐ STARTING METHOD ______
☐ LUBE ______

DRIVER BEARINGS (TYPE/NUMBER):

☐ RADIAL ______ / ______
☐ THRUST ______ / ______

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1	○ MIN DESIGN METAL TEMP (°C)	**REMARKS**
2	☐ **CASING:**	
3	MATERIAL (6.13)	
4	☐ MAX. ALLOWABLE CASING PRESS. (6.3.1) (barG)	
5	RELIEF VALVE SETTING (6.3.2) (barG)	
6	MARGIN FOR ACCUMULATION (barG)	
7	HYDRO PRESS. (barG)	
8	MAX. ALLOW. TEMP. (°C) MIN. OPER. TEMP. (°C)	
9	COOLING / HEATING JACKET ☐ YES ☐ NO **(6.3.6)**	
10	☐ **LINER**	
11	LINER MATERIAL (6.13)	
12	HARD COATING MATERIAL	
13	☐ **BEARING HOUSING MATERIAL**	
14	○ BEARING HOUSING COOLING	
15	☐ **ROTORS: (6.8.1)**	
16	DIAMETER (mm)	
17	EROSION HARD COATING	
18	TYPE FABRICATION	
19	MATERIAL (6.13)	
20	BRINELL HARDNESS. MAX. MIN.	
21	ROTOR LENGTH TO DIAMETER RATIO (L/D)	
22	ROTOR CLEARANCE (mm)	
23	MAX. DEFLECTION (mm)	
24	NON-CONTACT DESIGN	
25	☐ **SHAFT:**	
26	MATERIAL (6.13)	
27	DIA @ ROTORS (mm) DIA @ COUPLING (mm)	
28	SHAFT END. ☐ TAPERED ☐ CYLINDRICAL (7.2.9)	
29	☐ **TIMING GEARS: (6.8.2)**	
	○ **AGMA 11 QUALITY** ● **OTHER QUALITY**	
30	PITCH LINE DIAMETER (mm) TYPE	
31	MATERIAL	
32	**BEARINGS (TYPE/NUMBER):**	
33	☐ RADIAL /	
34	☐ THRUST /	
35	○ **SHAFT SEALS: (6.9)** ● **Per API 682 (data sheet)**	
36	○ **Seal Code** ● **Flush Plan**	
37	☐ INNER SEAL LEAK GUARANTEE (l/day/seal)	
38	○ SEAL OIL SYSTEMS (plan 54) ○ Per API 614 (Chapter 3)	
39	**BEARING TEMPERATURE DETECTORS:**	
40	○ AF BEARING OUTER RACE ○ OTHER	
41	○ TC TYPE ○ RTD TYPE	
42	**VIBRATION DETECTORS:**	
43	○ IN ACCORDANCE WITH: API 670	
44	○ OTHER (SPECIFY)	
45	○ TYPE ○ MODEL	
46	○ MFR.	
47	○ NO. AT EACH BEARING TOTAL NO.	
48	○ MONITOR SUPPLIED BY	
49	○ LOCATION ENCLOSURE	
50	○ MFR. ☐ MODEL	
51	☐ SCALE RANGE ○ ALARM. ☐ SET @ MILS	
52	○ SHUTDN: ☐ SET @ MILS ○ TIME DLY. SEC	
53	○ PHASE REFERENCE TRANSDUCER	

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VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.

ITEM NO. ______ SERVICE ______ JOB NO. ______

MANUFACTURER ______

LOCAL CONTROL PANEL:

FURNISHED BY: ◯ SUPPLIER ◯ PURCHASER ◯ OTHERS ______

◯ FREE STANDING ◯ WEATHERPROOF ◯ TOTALLY ENCLOSED ◯ EXTRA CUTOUTS

◯ VIBRATION ISOLATORS ◯ STRIP HEATERS ◯ PURGE CONNECTIONS

◯ ANNUNCIATOR: FURNISHED BY: ◯ VENDOR ◯ PURCHASER ◯ OTHERS ______

◯ ANNUNCIATOR LOCATED ON ◯ LOCAL PANEL ◯ MAIN CONTROL BOARD

◯ CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR

INSTRUMENT SUPPLIERS:

◯ PRESSURE GAUGES:	MFR.	______	SIZE & TYPE:	______
◯ TEMPERATURE GAUGES:	MFR.	______	SIZE & TYPE:	______
◯ LEVEL GAUGES:	MFR.	______	SIZE & TYPE:	______
◯ DIFF. PRESSURE GAUGES:	MFR.	______	SIZE & TYPE:	______
◯ PRESSURE TRANSMITTERS:	MFR.	______	SIZE & TYPE:	______
◯ DIFF. PRESSURE TRANSMITTERS:	MFR.	______	SIZE & TYPE:	______
◯ TEMPERATURE TRANSMITTERS:	MFR.	______	SIZE & TYPE:	______
◯ LEVEL SWITCHES:	MFR.	______	SIZE & TYPE:	______
◯ CONTROL VALVES:	MFR.	______	SIZE & TYPE:	______
◯ PRESSURE LIMITING VALVES: (7.5)	MFR.	______	SIZE & TYPE:	______
◯ SIGHT FLOW INDICATORS:	MFR.	______	SIZE & TYPE:	______
◯ FLOW INDICATOR:	MFR.	______	SIZE & TYPE:	______
◯ VIBRATION EQUIPMENT:	MFR.	______	SIZE & TYPE:	______
◯ SOLENOID VALVES	MFR.	______	SIZE & TYPE:	______
◯ ANNUNCIATOR:	MFR.	______	MODEL & NO. POINTS	______
◯ OTHER	MFR.		SIZE & TYPE:	

PRESSURE GAUGE REQUIREMENTS NOTE: ☐ SUPPLIED BY VENDOR ◯ SUPPLIED BY PURCHASER

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL	FUNCTION	LOCALLY MOUNTED	LOCAL PANEL
PUMP SUCTION	☐ ◯	☐ ◯	SEAL OIL PUMP DISCHARGE	☐ ◯	☐ ◯
PUMP DISCHARGE	☐ ◯	☐ ◯	SEAL OIL FILTER Δ P	☐ ◯	☐ ◯
LUBE OIL PUMP DISCHARGE	☐ ◯	☐ ◯	SEAL OIL SUPPLY	☐ ◯	☐ ◯
LUBE OIL FILTER Δ P	☐ ◯	☐ ◯	SEAL OIL DIFFERENTIAL	☐ ◯	☐ ◯
LUBE OIL SUPPLY	☐ ◯	☐ ◯	OTHER	☐ ◯	☐ ◯

TEMPERATURE GAUGE REQUIREMENTS:

FUNCTION	LOCALLY MOUNTED	LOCAL PANEL	**FUNCTION**	LOCALLY MOUNTED	LOCAL PANEL
LUBE DRAIN @ EA. BRG.	☐ ◯	☐ ◯	COOLER OIL INLET & OUTLET	☐ ◯	☐ ◯
PUMP RADIAL BEARING	☐ ◯	☐ ◯	LUBE OIL RESERVOIR	☐ ◯	☐ ◯
PUMP THRUST BEARING	☐ ◯	☐ ◯	SEAL OIL RESERVOIR	☐ ◯	☐ ◯
SEAL OIL OUTLET	☐ ◯	☐ ◯	PUMP SUCTION	☐ ◯	☐ ◯
OTHER	☐ ◯	☐ ◯	PUMP DISCHARGE	☐ ◯	☐ ◯

SWITCH CLOSURES:

ALARM CONTACTS SHALL: ◯ OPEN ◯ CLOSE TO SOUND ALARM AND BE NORMALLY ◯ ENERGIZED ◯ DE-ENERGIZED

SHUTDOWN CONTACTS SHALL: ◯ OPEN ◯ CLOSE TO TRIP AND BE NORMALLY ◯ ENERGIZED ◯ DE-ENERGIZED

NOTE: NORMAL CONDITION IS WHEN MPP IS IN OPERATION.

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VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.

ITEM NO. ______ SERVICE ______ JOB NO. ______

MANUFACTURER ______

	FUNCTION	ALARM	TRIP	FUNCTION	PRE-ALARM	TRIP
1	**ALARM & SHUTDOWN:**					
3	LOW LUBE OIL PRESSURE	___	___	PUMP VIBRATION	___	___
4	☐ ○ HI LUBE OIL FILTER Δ P	___	___	☐ ○ HI SEAL OIL OUTLET TEMP. (COOLER)	___	___
5	☐ ○ HI SEAL OIL FILTER Δ P	___	___	☐ ○ PUMP HI DISCH. TEMP.	___	___
6	☐ ○ LOW LUBE OIL RESERVOIR LEV.	___	___	☐ ○ HI LUBE OIL OUTLET TEMP. (COOLER)	___	___
7	☐ ○ LOW SEAL OIL RESERVOIR LEV.	___	___	☐ ○ DRIVER VIBRATION	___	___
8	☐ ○ HI SEAL OIL LEVEL	___	___	☐ ○ DRIVER SHUTDOWN	___	___
9	☐ ○ LOW SEAL OIL LEVEL	___	___	☐ ○ HI PUMP BRG. TEMP.	___	___
10	☐ ○ HI SEAL OIL PRESSURE	___	___	☐ ○ HI DRIVER BRG. TEMP.	___	___
11	☐ ○ LOW SEAL OIL PRESSURE	___	___	☐ ○ PUMP D P	___	___
12	☐ ○ AUX. SEAL OIL PUMP START	___	___	☐ ○ OTHER ______	___	___
13	☐ ○ AUX. LUBE OIL PUMP START	___	___	☐ ○ OTHER ______	___	___
14						

15 **MISCELLANEOUS INSTRUMENTATION:**
16 ☐ ○ DRIVER START/STOP ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD
17 ☐ ○ SIGHT FLOW INDICATORS, EACH BEARING HOUSING ☐ ○ SIGHT FLOW INDICATORS, EACH SEAL OIL RETURN LINE
18 ☐ ○ VIBRATION DETECTORS ☐ ○ VIBRATION AND BEARING TEMPERATURE MONITORS
19 VIBRATION READOUT LOCATED ON: ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD
20 ☐ ○ LEVEL GAUGES, LUBE AND/OR SEAL OIL RESERVOIR
21 ☐ ○ OTHER ______
22 **MISCELLANEOUS:**
23 ○ INSTRUMENT TAGGING REQUIRED.
24 ○ ALARM AND SHUTDOWN TRANSMITTERS SHALL BE SEPARATE.
25 PURCHASERS ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE BASEPLATE AND CONSOLE SHALL BE:
26 ☐ BROUGHT OUT TO TERMINAL BOXES. ☐ MADE DIRECTLY BY THE PURCHASER.
27 COMMENTS REGARDING INSTRUMENTATION: ______
28

29 **PUMP SHOP INSPECTION AND TESTS:**

		REQ'D	WITNESS	OBSERVE
31	SHOP INSPECTION (8.1)	○	○	○
32	HYDROSTATIC (8.3.2)	○	○	○
33	MECHANICAL RUN (8.3.5.1)	○	○	○
34	MECHANICAL RUN SPARE ROTORS	○	○	○
35	CASING LEAK TEST	○	○	○
36	PERFORMANCE TEST (GAS) (LIQUID)	○	○	○
37	COMPLETE UNIT TEST (8.3.7.2)	○	○	○
38	USE SHOP LUBE & SEAL SYSTEM	○	○	○
39	USE CONTRACT LUBE & SEAL SYSTEM	○	○	○
40	USE CONTRACT VIBRATION PROBES, ETC.	○	○	○
41	USE JOB BEARING VIBRATION AND TEMPERATURE			
42	TRANSDUCERS & MONITORS	○	○	○
43	PRESSURE PUMP TO FULL OPER. PRESS.	○	○	○
44	DISASSEMBLE-REASSEMBLE PUMP	○	○	○
45	AFTER TEST			
46	INSPECT BEARINGS AFTER TEST	○	○	○
47	SOUND-LEVEL TEST (8.3.7.3)	○	○	○
48	AUX. EQUIPMENT (8.3.4.3)	○	○	○
49	FULL-LOAD STRING TEST	○	○	○
50	GAS SLUG TEST	○	○	○
51	______	○	○	○
52	______	○	○	○
53				

MISCELLANEOUS:
☐ RECOMMEND STRAIGHT RUN OF PIPE DIA. BEFORE SUCTION
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION (7.8.2.d NOTE 4)
○ VENDOR REPRESENTATIVE OBSERVATION AT THE SITE
○ SPARE PARTS TO BE SUPPLIED
○ ROTOR ASSEMBLY ○ BEARINGS ○ SEALS
○ 2 YEARS SUPPLY ○ GASKETS, O-RINGS
○ START-UP/COMMISSIONING ○ OTHER

☐ **WEIGHTS:** (kg)
PUMP ______ DRIVER ______ BASEPLATE ______
ROTORS: PUMP DRIVER
LUBE OIL CONSOLE CONSOLE ______
SEAL OIL CONSOLE ______
MAX. FOR MAINTENANCE (IDENTIFY) ______
TOTAL SHIPPING WEIGHT ______

☐ **SPACE REQUIREMENTS:** (mm)

	L	W	H
COMPLETE UNIT	___	___	___
LUBE OIL CONSOLE	___	___	___
SEAL OIL CONSOLE	___	___	___

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1
2 APPLICABLE TO: PROPOSAL PURCHASE AS BUILT
3 FOR ____ UNIT ____
4 SITE ____ SERIAL NO. ____
5 SERVICE ____ NO. REQUIRED ____
6 MANUFACTURER ____ MODEL ____ DRIVER ____
7 NOTE: ○ INDICATES INFORMATION TO BE COMPLETED BY PURCHASER ☐ BY MANUFACTURER ○ BY MANUFACTURER OR PURCHASER

OPERATING CONDITIONS

			MIN	NORMAL	RATED	MAX (1)
9						
10	○ CAPACITY:	(BPD)				
11	○ OTHER CAPACITY:	(gpm)				
12	○ SUCTION PRESSURE :	(psig)				
13	○ DISCHARGE PRESSURE:	(psig)				
14	○ DIFFERENTIAL PRESSURE	(psi)				

15 ○ DUTY CYCLE ○ CONTINUOUS ○ INTERMITTENT
16 (1) Maximum - mechanical design

17 **PUMPED FLUID**

18 ○ TYPE OR NAME OF PUMPED FLUID ____

			MIN	NORMAL	RATED
19					
20	○ TEMPERATURE:	(°F)			
21	○ VAPOR PRESS.:	(psia)			
22	○ RELATIVE DENSITY (SG):				
23	○ VISCOSITY:	(cP)			

24 ○ SPECIFIC HEAT ____ Cp (BTU/lb °F)
25 ○ CORROSIVE/EROSIVE AGENTS ____
26 ○ CHLORIDE CONCENTRATION (ppm) ____
27 ○ H_2S CONCENTRATION (ppm) ____
28 FLUID ○ HAZARDOUS ○ FLAMMABLE ○ OTHER ____
29 ○ EROSIVE ○ CORROSIVE

30 **MULTIPHASE CONDITIONS**

31 ○ GAS DESCRIPTION ____ (SEE GAS ANALYSIS)
32 ○ SETTLE OUT PRESSURE ____ (psia)
33 ○ GAS VOLUME or GVF % MIN ____ MAX ____
34 ○ ENTRAINED ○ SLUG FLOW ○ OTHER ____
35 ○ SOLIDS PARTICLE SIZE DISTRIBUTION & MIN/MAX ____ (μ)
36 ○ CONCENTRATION ____ ○ HARDNESS ____
37 ○ SHAPE

38 **PERFORMANCE**

39 ☐ RATED CAPACITY (gpm) ____
40 ☐ RATED SPEED (rpm) ____
41 ☐ RATED VOLUMETRIC EFFICIENCY (%) ____
42 ☐ RATED PUMP EFFICIENCY (%) ____
43 ☐ REQUIRED POWER @ MAXIMUM VISCOSITY (BHP) ____
44 ☐ REQUIRED POWER @ PRESSURE LIMITING (BHP) ____
45 ☐ REQUIRED POWER @ RATED CONDITION (BHP) ____
46 ☐ MAXIMUM ALLOWABLE SPEED (rpm) ____
47
48 **REMARKS:** ____
49 ____
50 ____
51 ____
52 ____
53 ____
54 ____

GAS ANALYSIS

GAS ANALYSIS	M.W.	NOR-MAL	MAX-IMUM	REMARKS
○ MOL % ○ ____				
AIR	28.966			
OXYGEN	32.000			
NITROGEN	28.016			
WATER VAPOR	18.016			
CARBON MONOXIDE	28.010			
CARBON DIOXIDE	44.010			
HYDROGEN SULFIDE	34.076			
HYDROGEN	2.016			
METHANE	16.042			
ETHYLENE	28.052			
ETHANE	30.068			
PROPYLENE	42.078			
PROPANE	44.094			
I-BUTANE	58.120			
n-BUTANE	58.120			
I-PENTANE	72.146			
n-PENTANE	72.146			
HEXANE PLUS				
TOTAL				
AVG. MOL. WT.				

SUPPLIER WITH UNIT RESPONSIBILITY
○ PUMP MANUFACTURER ○ OTHER

APPLICABLE SPECIFICATIONS:
API 676 POSITIVE DISPLACEMENT ROTARY PUMPS
○ GOVERNING SPECIFICATION (IF DIFFERENT) ____
○ MOTOR (See Page 6) ____
○ NACE MR0103 (6.13.2.13) ○ NACE MR0175
○ NOISE ____ SOUND LEVEL ____ dB @ ____

LUBE AND SEAL OIL CIRCULATION SYSTEMS (API 614 chapter 3)
○ LUBE SYSTEM ○ SEAL OIL SYSTEMS (plan 54) ○ OTHER

PAINTING: (8.4.3.1)
○ MANUFACTURER'S STD. ○ OTHER

PREPARE FOR SHIPMENT: (8.4)
○ DOMESTIC ○ EXPORT ○ EXPORT BOXING REQ'D
○ LONG TERM STORAGE FOR ____ MONTHS

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LOCATION:
○ INDOOR ○ HEATED ○ UNDER ROOF
○ OUTDOOR ○ UNHEATED ○ PARTIAL SIDES
○ GRADE ○ MEZZANINE ○ ____
○ ELECTRICAL AREA CLASS ○ NON-HAZARDOUS
CL ____ GR ____ DIV. ____ TEMP CLASS ____
ZONE ____ CLASS ____ GROUP ____
○ WINTERIZATION REQ'D. ○ TROPICALIZATION REQ'D.

SITE DATA:
○ ELEVATION ____ (ft) BAROMETER ____ (psia)
○ RANGE OF AMBIENT TEMPS.:

		DRY BULB	WET BULB
SITE RATED	(°F)		
NORMAL	(°F)		
MAXIMUM	(°F)		
MINIMUM	(°F)		

UNUSUAL CONDITIONS:
○ DUST ○ FUMES ○ SALT ATMOSPHERE
○ OTHER ____

UTILITY CONDITIONS:

STEAM		DRIVERS		HEATING	
INLET	MIN.	(psig)	(°F)	(psig)	(°F)
	NORM	(psig)	(°F)	(psig)	(°F)
	MAX.	(psig)	(°F)	(psig)	(°F)
EXHAUST	MIN.	(psig)	(°F)	(psig)	(°F)
	NORM	(psig)	(°F)	(psig)	(°F)
	MAX.	(psig)	(°F)	(psig)	(°F)

ELECTRICITY:

	DRIVERS	HEATING	CONTROL	SHUT-DOWN
VOLTAGE				
HERTZ				
PHASE				

COOLING WATER
TEMP. INLET ____ (°F) MAX. RETURN ____ (°F)
PRESS. NORM ____ (psig) DESIGN ____ (psig)
MIN. RETURN ____ (psig) MAX. ALLOW D P ____ (psia)
WATER SOURCE ____

INSTRUMENT AIR:
MAX PRESS ____ (psig) MIN. ____ (psig)

☐ **TOTAL UTILITY CONSUMPTION:**
COOLING WATER ____ (gph)
STEAM, NORMAL ____ (lb/hr)
STEAM, MAX ____ (lb/hr)
INSTRUMENT AIR ____ (scfm)
POWER (DRIVER) ____ (HP)
POWER (AUXILIARIES): ____ (HP)

BASEPLATE (7.4)
○ COMMON (UNDER PUMP & DRIVER) ○ OTHER ____
○ DECKED WITH NON-SKID DECK PLATE (7.4.12) ○ OPEN CONSTR.
○ DRIP RIM ○ WITH OPEN DRAIN ○ SUBPLATE
○ HORIZONTAL ADJUSTING SCREWS FOR EQUIPMENT (7.4.4)
○ EPOXY GROUT/EPOXY PRIMER

REMARKS ____

☐ **CONNECTIONS:**

	SIZE	ANSI RATING	FACING	POSI-TION
CASING (4.3)				
INLET				
DISCHARGE				
SKID INLET				
SKID OUTLET				

☐ **OTHER CONNECTIONS:**

SERVICE:	NO	SIZE	TYPE / ANSI RATING
LUBE OIL OUTLET			
SEAL OIL INLET			
SEAL OIL OUTLET			
CASING DRAINS			
VENTS			
COOLING WATER			
CASE PRESSURE			
TEMPERATURE			
PURGE FOR: ____			

DRIVER TYPE
○ INDUCTION MOTOR ○ STEAM TURBINE ○ GEAR ○ OTHER

DRIVE MECHANISM
○ DIRECT-COUPLED ○ ASD ○ OTHER ____
○ COUPLING MANUFACTURER ____
○ COUPLING TYPE ____
☐ RATING (MAX TORQUE) ____ ○ MODEL ____
○ SPACER LENGTH ____ (IN) ○ S.F. ____
○ COUPLING BALANCED ○ MANF STD ○ ISO 1940-1 G6.3 (7.2.3)
○ COUPLING PER API 671 (7.2.4)
○ COUPLING HUB ATTACHMENT ○ TAPERED
○ STRAIGHT ○ KEYED ○ HYRDRAULIC FIT

COUPLING GUARD TYPE
○ STEEL ○ BRASS ○ NON-METALLIC ○ OTHER
○ NON SPARK COUPLING GUARD (7.2.15c) ____

○ **MOTOR DRIVER (7.1) (SEE MOTOR DATA SHEET)**
○ IEEE 841 ○ API 541 ○ API 546 ○ OTHER
○ ASD SUPPLIED BY ○ PURCHASER ○ MOTOR SUPPLIER
☐ MANUFACTURER ____ ☐ TYPE ____
☐ FRAME ____ ○ ENCLOSURE ____
○ HORIZONTAL ○ VERTICAL
☐ (HP) ____ (rpm) ____
○ VOLTS ____ PHASE ____ HERTZ ____ SERVICE FACTOR ____
○ VARIABLE SPEED RANGE ____ (rpm)
○ MINIMUM STARTING VOLTAGE (7.1.2.2) ____
○ INSULATION ____ ○ TEMP. RISE ____
○ FULL LOAD AMPS ____
○ LOCKED ROTOR AMPS ____
○ STARTING METHOD ____
○ LUBE ____

DRIVER BEARINGS (TYPE/NUMBER):
☐ RADIAL ____ / ____
☐ THRUST ____ / ____

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REMARKS

1	○ MIN DESIGN METAL TEMP (°F)
2	☐ **CASING:**
3	MATERIAL (6.13)
4	☐ MAX. ALLOWABLE CASING PRESS. (6.3.1) (psig)
5	RELIEF VALVE SETTING (6.3.2) (psig)
6	MARGIN FOR ACCUMULATION (psig)
7	HYDRO PRESS. (psig)
8	MAX. ALLOW. TEMP. (°F) MIN. OPER. TEMP. (°F)
9	COOLING / HEATING JACKET ☐ YES ☐ NO **(6.3.6)**
10	☐ **LINER**
11	LINER MATERIAL (6.13)
12	HARD COATING MATERIAL
13	☐ **BEARING HOUSING MATERIAL**
14	○ BEARING HOUSING COOLING
15	☐ **ROTORS: (6.8.1)**
16	DIAMETER (in)
17	EROSION HARD COATING
18	TYPE FABRICATION
19	MATERIAL (6.13)
20	BRINELL HARDNESS. MAX. MIN.
21	ROTOR LENGTH TO DIAMETER RATIO (L/D)
22	ROTOR CLEARANCE (in)
23	MAX. DEFLECTION (in)
24	NON-CONTACT DESIGN
25	☐ **SHAFT:**
26	MATERIAL (6.13)
27	DIA @ ROTORS (in) DIA @ COUPLING (in)
28	SHAFT END. ☐ TAPERED ☐ CYLINDRICAL (7.2.9)
29	☐ **TIMING GEARS: (6.8.2)**
	○ **AGMA 11 QUALITY** ● **OTHER QUALITY**
30	PITCH LINE DIAMETER (in) TYPE
31	MATERIAL
32	**BEARINGS (TYPE/NUMBER):**
33	☐ RADIAL /
34	☐ THRUST /
35	○ **SHAFT SEALS: (6.9)** ● **Per API 682 (data sheet)**
36	○ **Seal Code** ● **Flush Plan**
37	☐ INNER SEAL LEAK GUARANTEE (gal/day/seal)
38	○ SEAL OIL SYSTEMS (plan 54) ○ Per API 614 (Chapter 3)
39	**BEARING TEMPERATURE DETECTORS:**
40	○ AF BEARING OUTER RACE ○ OTHER
41	○ TC TYPE ○ RTD TYPE
42	**VIBRATION DETECTORS:**
43	○ IN ACCORDANCE WITH: API 670
44	○ OTHER (SPECIFY)
45	○ TYPE ○ MODEL
46	○ MFR.
47	○ NO. AT EACH BEARING TOTAL NO.
48	○ MONITOR SUPPLIED BY
49	○ LOCATION ENCLOSURE
50	○ MFR. ☐ MODEL
51	☐ SCALE RANGE ○ ALARM. ☐ SET @ MILS
52	○ SHUTDN: ☐ SET @ MILS ○ TIME DLY. SEC
53	○ PHASE REFERENCE TRANSDUCER

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1 VENDOR MUST FURNISH ALL PERTINENT DATA FOR THIS SPECIFICATION SHEET BEFORE RETURNING.
2 ITEM NO. ______ SERVICE ______ JOB NO. ______
3 MANUFACTURER ______
4 **LOCAL CONTROL PANEL:**
5 FURNISHED BY: SUPPLIER PURCHASER OTHERS ______
6 FREE STANDING WEATHERPROOF TOTALLY ENCLOSED EXTRA CUTOUTS
7 VIBRATION ISOLATORS STRIP HEATERS PURGE CONNECTIONS
8 ANNUNCIATOR: FURNISHED BY: VENDOR PURCHASER OTHERS ______
9 ANNUNCIATOR LOCATED ON LOCAL PANEL MAIN CONTROL BOARD
10 CUSTOMER CONNECTIONS BROUGHT OUT TO TERMINAL BOXES BY VENDOR
11 **INSTRUMENT SUPPLIERS:**

12	PRESSURE GAUGES:	MFR.	SIZE & TYPE:	
13	TEMPERATURE GAUGES:	MFR.	SIZE & TYPE:	
14	LEVEL GAUGES:	MFR.	SIZE & TYPE:	
15	DIFF. PRESSURE GAUGES:	MFR.	SIZE & TYPE:	
16	PRESSURE TRANSMITTERS:	MFR.	SIZE & TYPE:	
17	DIFF. PRESSURE TRANSMITTERS:	MFR.	SIZE & TYPE:	
18	TEMPERATURE TRANSMITTERS:	MFR.	SIZE & TYPE:	
19	LEVEL SWITCHES:	MFR.	SIZE & TYPE:	
20	CONTROL VALVES:	MFR.	SIZE & TYPE:	
21	PRESSURE LIMITING VALVES: (7.5)	MFR.	SIZE & TYPE:	
22	SIGHT FLOW INDICATORS:	MFR.	SIZE & TYPE:	
23	FLOW INDICATOR:	MFR.	SIZE & TYPE:	
24	VIBRATION EQUIPMENT:	MFR.	SIZE & TYPE:	
25	SOLENOID VALVES	MFR.	SIZE & TYPE:	
26	ANNUNCIATOR:	MFR.	MODEL & NO. POINTS	
27	OTHER	MFR.	SIZE & TYPE:	

28 **PRESSURE GAUGE REQUIREMENTS** **NOTE:** **SUPPLIED BY VENDOR** **SUPPLIED BY PURCHASER**

		LOCALLY	LOCAL		LOCALLY	LOCAL
29–30	FUNCTION	MOUNTED	PANEL	FUNCTION	MOUNTED	PANEL
31	PUMP SUCTION			SEAL OIL PUMP DISCHARGE		
32	PUMP DISCHARGE			SEAL OIL FILTER Δ P		
33	LUBE OIL PUMP DISCHARGE			SEAL OIL SUPPLY		
34	LUBE OIL FILTER Δ P			SEAL OIL DIFFERENTIAL		
35	LUBE OIL SUPPLY			OTHER		

36 **TEMPERATURE GAUGE REQUIREMENTS:**

		LOCALLY	LOCAL		LOCALLY	LOCAL
37–38	**FUNCTION**	MOUNTED	PANEL	**FUNCTION**	MOUNTED	PANEL
39	LUBE DRAIN @ EA. BRG.			COOLER OIL INLET & OUTLET		
40	PUMP RADIAL BEARING			LUBE OIL RESERVOIR		
41	PUMP THRUST BEARING			SEAL OIL RESERVOIR		
42	SEAL OIL OUTLET			PUMP SUCTION		
43	OTHER			PUMP DISCHARGE		

44 **SWITCH CLOSURES:**
45 ALARM CONTACTS SHALL: OPEN CLOSE TO SOUND ALARM AND BE NORMALLY ENERGIZED DE-ENERGIZED
46 SHUTDOWN CONTACTS SHALL: OPEN CLOSE TO TRIP AND BE NORMALLY ENERGIZED DE-ENERGIZED
47 **NOTE: NORMAL CONDITION IS WHEN MPP IS IN OPERATION.**
48
49

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MANUFACTURER ________

ALARM & SHUTDOWN:

FUNCTION	ALARM	TRIP
LOW LUBE OIL PRESSURE	___	___
☐ ○ HI LUBE OIL FILTER Δ P	___	___
☐ ○ HI SEAL OIL FILTER Δ P	___	___
☐ ○ LOW LUBE OIL RESERVOIR LEV.	___	___
☐ ○ LOW SEAL OIL RESERVOIR LEV.	___	___
☐ ○ HI SEAL OIL LEVEL	___	___
☐ ○ LOW SEAL OIL LEVEL	___	___
☐ ○ HI SEAL OIL PRESSURE	___	___
☐ ○ LOW SEAL OIL PRESSURE	___	___
☐ ○ AUX. SEAL OIL PUMP START	___	___
☐ ○ AUX. LUBE OIL PUMP START	___	___

FUNCTION	PRE-ALARM	TRIP
PUMP VIBRATION	___	___
☐ ○ HI SEAL OIL OUTLET TEMP. (COOLER)	___	___
☐ ○ PUMP HI DISCH. TEMP.	___	___
☐ ○ HI LUBE OIL OUTLET TEMP. (COOLER)	___	___
☐ ○ DRIVER VIBRATION	___	___
☐ ○ DRIVER SHUTDOWN	___	___
☐ ○ HI PUMP BRG. TEMP.	___	___
☐ ○ HI DRIVER BRG. TEMP.	___	___
☐ ○ PUMP D P	___	___
☐ ○ OTHER ________	___	___
☐ ○ OTHER ________	___	___

MISCELLANEOUS INSTRUMENTATION:

☐ ○ DRIVER START/STOP ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD
☐ ○ SIGHT FLOW INDICATORS, EACH BEARING HOUSING ☐ ○ SIGHT FLOW INDICATORS, EACH SEAL OIL RETURN LINE
☐ ○ VIBRATION DETECTORS ☐ ○ VIBRATION AND BEARING TEMPERATURE MONITORS
VIBRATION READOUT LOCATED ON: ☐ LOCAL PANEL ☐ SEPARATE PANEL ☐ MAIN BOARD
☐ ○ LEVEL GAUGES, LUBE AND/OR SEAL OIL RESERVOIR
☐ ○ OTHER ________

MISCELLANEOUS:

○ INSTRUMENT TAGGING REQUIRED.
○ ALARM AND SHUTDOWN TRANSMITTERS SHALL BE SEPARATE.
PURCHASERS ELECTRICAL AND INSTRUMENT CONNECTIONS WITHIN THE CONFINES OF THE BASEPLATE AND CONSOLE SHALL BE:
☐ BROUGHT OUT TO TERMINAL BOXES. ☐ MADE DIRECTLY BY THE PURCHASER.
COMMENTS REGARDING INSTRUMENTATION: ________

PUMP SHOP INSPECTION AND TESTS:

	REQ'D	WITNESS	OBSERVE
SHOP INSPECTION (8.1)	○	○	○
HYDROSTATIC (8.3.2)	○	○	○
MECHANICAL RUN (8.3.5.1)	○	○	○
MECHANICAL RUN SPARE ROTORS	○	○	○
CASING LEAK TEST	○	○	○
PERFORMANCE TEST (GAS) (LIQUID)	○	○	○
COMPLETE UNIT TEST (8.3.7.2)	○	○	○
USE SHOP LUBE & SEAL SYSTEM	○	○	○
USE CONTRACT LUBE & SEAL SYSTEM	○	○	○
USE CONTRACT VIBRATION PROBES, ETC.	○	○	○
USE JOB BEARING VIBRATION AND TEMPERATURE TRANSDUCERS & MONITORS	○	○	○
PRESSURE PUMP TO FULL OPER. PRESS.	○	○	○
DISASSEMBLE-REASSEMBLE PUMP AFTER TEST	○	○	○
INSPECT BEARINGS AFTER TEST	○	○	○
SOUND-LEVEL TEST (8.3.7.3)	○	○	○
AUX. EQUIPMENT (8.3.4.3)	○	○	○
FULL-LOAD STRING TEST	○	○	○
GAS SLUG TEST	○	○	○
________	○	○	○
________	○	○	○

MISCELLANEOUS:

☐ RECOMMEND STRAIGHT RUN OF PIPE DIA. BEFORE SUCTION
○ VENDOR'S REVIEW & COMMENTS ON PURCHASER'S PIPING & FOUNDATION (7.8.2.d NOTE 4)
○ VENDOR REPRESENTATIVE OBSERVATION AT THE SITE
○ SPARE PARTS TO BE SUPPLIED
○ ROTOR ASSEMBLY ○ BEARINGS ○ SEALS
○ 2 YEARS SUPPLY ○ GASKETS, O-RINGS
○ START-UP/COMMISSIONING ○ OTHER

☐ **WEIGHTS:** (lb)
PUMP ____ DRIVER ____ BASEPLATE ____
ROTORS: PUMP DRIVER
LUBE OIL CONSOLE CONSOLE ________
SEAL OIL CONSOLE ________
MAX. FOR MAINTENANCE (IDENTIFY) ________
TOTAL SHIPPING WEIGHT ________

☐ **SPACE REQUIREMENTS:** (in)

	L	W	H
COMPLETE UNIT	___	___	___
LUBE OIL CONSOLE	___	___	___
SEAL OIL CONSOLE	___	___	___

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ROTARY PUMP (API 676-3RD)

JOB NO. ______ ITEM NO.(S) ______
REQ / SPEC NO. ______ / ______

PRESSURE DESIGN CODES
WELDING REQUIREMENTS
PURCHASER DEFINED MATERIAL INSPECTIONS

PURCH ORDER NO. ______ DATE ______
INQUIRY NO ______ BY ______
REVISION NO. ______ DATE: ______

1	APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ○ AS BUILT
2	FOR ______ UNIT ______
3	SITE ______ SERVICE ______
4	NO. REQ ______ PUMP SIZE ______ TYPE ______ NO. STAGES ______
5	MANUFACTURER ______ MODEL ______ SERIAL NO. ______
6	
7	NOTES: INFORMATION BELOW TO BE COMPLETED: ○ BY PURCHASER □ BY MANUFACTURER ○ BY MANUFACTURER OR PURCHASER
8	**PRESSURE VESSEL DESIGN CODE REFERENCES.**
9	THESE REFERENCES MUST BE LISTED BY THE MANUFACTURER
10	
11	
12	**WELDING AND REPAIRS (6.13.5 & 6.13.1)**
13	THESE REFERENCES MUST BE LISTED BY THE PURCHASER. (DEFAULT TO TABLE 5 IF NO PURCHASER PREFERENCE IS STATED)
14	○ ALTERNATE WELDING CODES AND STANDARDS (6.13.5.1)

	Welding Requirement (Applicable Code or Standard)	Purchaser defined	Default per Table 5
16	Welder/operator qualification	○	○
17	Welding procedure qualification	○	○
18	Non-pressure retaining structural welding such as baseplates or supports	○	○
19	Magnetic Particle or Liquid Penetrant examination of plate edges	○	○
20	Postweld heat treatment	○	○
21	Postweld heat treatment of casing fabrication welds	○	○

22	**WELDING APPROVALS:**
23	○ Submit Weld Procedures for approval
24	○ Submit Pressure Boundary Weld Maps for approval on major weld repairs at pump mfr.
25	**MATERIAL AND OTHER INSPECTIONS (8.2.2.1.1)(8.2.3.1)**
26	THESE REFERENCES MUST BE LISTED BY THE PURCHASER (DEFAULT TO TABLE 6 IF NO PURCHASER METHOD PREFERENCE IS STATED)
27	ALTERNATIVE MATERIAL INSPECTIONS AND ACCEPTANCE CRITERIA (SEE TABLE 6)

	Type of inspection	Para.	List Methods (if not API 676 defaults)	Press Bdry. Fabs	Piping	Press. Bdry. Cstgs.	Witness
30	○ MSS-SP55 Visual casting Inspection	6.13.3.2				○	○
31	○ Magnetic particle inspection at foundry	8.2.2.1.1	○	○		○	○
32	○ Liquid penetrant inspection at foundry	8.2.2.1.1	○	○		○	○
33	○ RT critical areas casing casting at foundry	8.2.2.1.1	○	○		○	○
34	○ Magnetic particle insp. - finished machined	8.2.2.1.1	○	○		○	○
35	○ Liquid penetrant insp. - finished machined	8.2.2.1.1	○	○		○	○
36	○ RT critical areas casing - near fin. mach'd.	8.2.2.1.1	○	○		○	○
37	○ MT or PT of Fabricated plate edges	6.13.5.3d	○	○			○
38	○ MT or PT case attachment welds	8.2.2.1.1	○	○			○
39	○ MT or PT rotor at foundry	8.2.2.1.1	○			○	○
40	○ RT butt welds in aux. piping		○ ASME B31.3 or 31.4 or 31.8		○		○
41	○ MT or PT rotor - finished machined	8.2.2.1.1	○	○		○	○
42	○ PMI all alloy pressure bndry components	8.2.4		○			○
43	○ PMI alloy piping	8.2.4			○		○
44	○ PMI alloy rotors	8.2.4			○		○
44	○ Barstock with UT certificate for shaft	8.2.2.1.1	○	○	○		
45	○ Charpy Impact Test pressure bndry parts	6.13.6.5	○	○	○	○	○
46	○ Casing caliper thickness check			○		○	○
47	○ Rotor balance to ISO 1940 G2.5	6.8.1.9					○
48	○ Hardness of parts, welds & HAZ						
49	○ Record Final assembly Clearances	8.2.1.1f					○

50	Material Test Reports 6.13.2.10: ○ Casing ○ Rotor / Vanes ○ Stators ○ Shaft ○ Bolting ○ Aux Piping ○
51	HAZ is "heat affedted zone"

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REQ / SPEC NO. **0** / **0**
PURCH ORDER NO. **0** DATE **0**
INQUIRY NO **0** BY **0**
REVISION NO. **0** DATE: **0**

PRESSURE DESIGN CODES
WELDING REQUIREMENTS
PURCHASER DEFINED MATERIAL INSPECTIONS

1	APPLICABLE TO: ○ PROPOSALS ○ PURCHASE ☐ AS BUILT	
2	FOR **0**	UNIT **0**
3	SITE **0**	SERVICE **0**
4	NO. REQ **0** PUMP SIZE **0**	TYPE **0** NO. STAGES **0**
5	MANUFACTURER **0**	MODEL **0** SERIAL NO. **0**
7	**PAGE No. / LINE No.**	**REMARKS**
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Annex B
(informative)

Factors Affecting Twin Screw Pump Wear Rate and Volumetric Efficiency

B.1 General

The purpose of this annex is to provide users with a general understanding of factors that may affect the volumetric efficiency of twin screw pumps. Pump design is often a compromise based on several factors present in the specific application.

Volumetric efficiency is the ratio of the pump rated point flow to the total theoretical displacement per unit time.

NOTE Volumetric efficiency is normally expressed as a percentage.

B.2 Major Factors

Twin screw pump wear rate and volumetric efficiency can be significantly affected over time by several competing factors. These are:

a) particulate (quantity, hardness, shape, and size distribution);

b) temperature and viscosity (pumped fluid viscosity);

c) gas volume fraction (GVF);

d) pump speed (regarding streams with little or no particulate); and

e) differential pressure.

Items a) to c) are fluid characteristics, so it is important to understand the nature of the fluid being pumped.

B.2.1 Particulate

B.2.1.1 Quantity

The quantity of the particulate will determine if it needs to be considered as a design requirement. If there is little or no particulate, it does not need to be considered; however, if significant amounts of particulate are in the pumped stream, its effect on pump wear, and, in the long term, the pump's efficiency and ability to perform will be affected. It is recommended that unless a pumped stream has been proven to have no particulate, it should be assumed that particulate will be in the stream, and will need to be addressed by the pump design.

B.2.1.2 Hardness

The hardness of the particulate also determines the extent of the design considerations required for the pump. Logically, the softer the particulate, the less of a design consideration it is. The normal hardness of the design materials for the pump screws and the case can handle soft particulate, either grinding it between the screw outer diameter (OD) and the bore inner diameter (ID) or between the screw OD and the adjacent screw's root diameter. Hard particulate not only opens these clearances, but the screw edges become rounded. These changes cause the pump to become inefficient by increasing the "slip" or backflow from the higher pressure downstream side of the screw to the lower pressure upstream side of the screw, that is, across the screw lock. As these clearances open by erosion, the pump's ability to produce a required flowrate is diminished, the slip is increased, and the volumetric efficiency is reduced. The speed of the pump must be increased to regain the required flowrate, but with this increased speed, the rate of erosion is increased, and the cycle is repeated.

B.2.1.3 Shape

The same is true for the shape of the particulate. The sharper the edges of the particulate the more rapid is the erosion rate of these same clearances with the resulting increase in slip and loss of volumetric efficiency.

B.2.1.4 Size Distribution

The size distribution of the particulate plays a similar role. Particles that are relatively large compared to the clearances will tend to pass along the axis of the pump's shaft from suction to discharge, but they tend to cause the pump to bind. Experience has shown that it is best to prevent ingress of large particles into the pump by appropriate inlet protection, such as, inlet screens with differential pressure alarms. Those particles that are of the same order of magnitude as the pump's clearances tend to get wedged into the clearances producing wear, opening the clearances. In designing the pump, the clearances can be opened to allow the microsized particles to pass between the screw OD and the bore ID, reducing the wear. Since the clearance is increased, the total effective flowrate is decreased, and the amount of slip is increased, with a resulting decrease in the pump's efficiency.

B.2.1.5 Particulate Wear Mitigation

The pump's design can be modified to mitigate the affects of particulate by:

a) changing the screw and case materials;

b) designing the case to accept a hardened or coated replaceable liner;

c) hardening the entire screw surface by processes such as boriding or nitriding;

d) hardening the OD of the screws (the screw seals) by processes such as hardfacing;

e) changing the screw profile (screw flank shape);

f) increasing the number of screw seals (turns, closures, or screw locks) in the screw set;

g) opening the clearances between the circumference of the screws (screw OD) and the case or case liner (bore ID) and between the circumference of the screws (screw OD) and the outside diameter of the adjacent screw's root diameter; and

h) reducing the design operating speed for a given pump size.

A further explanation of some of the above follows.

B.2.1.5.1 Changing the Screw Profile (Flank Shape) [Item e) on the Previous List]

Changing the screw profile between the adjacent screw flanks to a gap appropriate to keep out the larger particulate, but pass the smaller-sized particulate, will reduce the erosion on the flanks. Though this helps to reduce erosion, the slip will be increased. An alternate method is to allow a pump to "wear-in" to achieve uniform clearances appropriate to the nature of the fluid pumped, but this wear-in volumetric efficiency must be predetermined and must be the one that the pump design is based upon. This method may also wear through any hard coating on the rotors.

B.2.1.5.2 Increasing the Number of Seals (Turns, Closures, or Screw Locks) [Item f) on the Previous List]

Increasing the number of seals (turns, closures, or screw locks) in the screw set, for the same total pressure differential across the pump flanges, reduces the differential pressure built across each screw seal. This reduces the velocity of the slippage over each screw seal from the high pressure to the low pressure side of each closure, and therefore reduces the erosion rate.

B.2.1.5.3 Opening the Clearances [Item g) on the Previous List]

Opening the clearances between the screw OD and the casing bore ID, and between the screw OD and the root diameter of the adjacent screw's shaft, reduces the velocity of the fluid that is slipping back within these clearance regions. If this fluid was to contain solid particulate, the affect of jetting erosion within the pumping internals could be reduced, since the carrying velocity of the liquid has been diminished. These increased clearances would also permit larger particles to more freely travel across these shaft land areas, without contributing to additional wear and subsequent further increase of the radial clearance between the screw OD and the casing bore ID. A design modification of this type would initially result in a lower volumetric efficiency for the pump, although overall the volumetric efficiency of the pump when conveying fluids with solid particulate may be more stable.

B.2.1.5.4 Reducing the Design Operating Speed [Item h) on the Previous List]

Erosion is related to velocity by a power of roughly 3.5 ($e \sim v^{3.5}$). So, for a given diameter screw the higher the initial pump speed, the higher the screw's circumferential or tip velocity, and the higher the built-in erosion rate. Of course, the higher the erosion rate, the more quickly the slip increases and more quickly the pump's volumetric efficiency is reduced. The pump's speed must then be increased to overcome this increased slip and reduction of the pump's flowrate. This increase in pump speed causes an even higher screw tip velocity leading to more rapid erosion, which causes even more slip and further loss of efficiency. This cycle is continually repeated ever more frequently. Conversely, if the initial design speed of the pump is low (e.g. 900 rpm or 1200 rpm) for a given diameter screw the initial screw tip velocity is lowered, and the rate of erosion will then be lower than if the initial speed of the pump is 3600 rpm. While this means that for a certain flowrate, the pump will be larger and initially cost more, the pump's volumetric efficiency will be able to be maintained for a longer period of time. For a twin screw to maintain its volumetric efficiency, therefore, the lower the initial design speed and tip velocity, the lower the initial erosion rate, and the longer the design volumetric efficiency is able to be maintained.

B.2.2 Temperature and Viscosity

The pump design should be adjusted to compensate for maximum operating conditions. In order to handle high pumped fluid flowing temperatures [above 148 °C (above 300 °F)], the clearances must be set appropriately depending on the materials of construction and the design to allow for thermal growth of the components. For example, the higher the temperature, the greater the clearances must be opened between the screw ODs and the bore ID. This increased clearance means that the pump will have increased slip until it is hot and cannot provide the rated flow until fully heated.

NOTE Care must also be taken to not change temperature quickly or flow hot fluid into a cold pump as rapid temperature change can cause dimensional distortion with severe consequences to the pump.

The apparent viscosity of the pumped fluid is an important design parameter. The higher the apparent fluid flowing viscosity the more the fluid seals the clearance between the screw OD and the bore ID. This fluid seal reduces the slip and thereby maintains the volumetric efficiency of the pump over time.

Also, the higher the viscosity, the more any contained particulate is coated by the fluid which then acts as a buffer around the particulate. The result is that the pump sustains less erosion as the particulate passes through it.

Existing data demonstrates that low viscosity fluids (similar to water), and low viscosity fluids containing GVFs of about 70 %, cause MPPs to lose volumetric efficiency as the pump's differential pressure is increased. This loss of volumetric efficiency with increasing differential pressure seems to be lessened the higher the GVF until the reduction is minimized at GVFs above 90 %.

B.2.3 Gas Volume Fraction (GVF)

Volumetric efficiency is often counter-intuitive if high GVF fluids are being pumped. Pressure is developed in the last lock of the pump. Volumetric efficiency remains relatively constant as the differential pressure increases. Pump wear from the particulate in the liquid phase may be seen at the OD-flank intersection of the screw. Sufficient liquid must be maintained in the pump to maintain the seals in the pumping elements in order to maintain flow.

B.2.4 Pump Speed (Regarding Streams with Little or No Particulate)

Since the amount of slip is a constant at a given viscosity and pressure differential, the higher the pump speed the higher the calculated total amount of volume transferred and the higher the calculated volumetric efficiency.

B.2.5 Conclusions

Those items which negatively impact twin screw wear rate and volumetric efficiency are:

a) streams containing high quantities of hard, sharp-edged, clearance-sized particulate,

b) low viscosity fluid streams,

c) high rotating speed (particulate laden),

d) low rotating speed (clean),

e) high clearance screw profiles (lower efficiency but with less potential for wear),

f) a few number of screw seals (turns or closures), and

g) high differential pressure.

Conversely, those items which positively impact wear rate and volumetric efficiency are:

a) streams containing little or no particulate,

b) high apparent viscosity fluid streams,

c) low rotating speed (particulate laden),

d) high rotating speed (clean),

e) low clearance screw profiles (higher efficiency but with more potential for wear),

f) many screw seals (turns or closures), and

g) low differential pressure.

Keep in mind that this annex is just meant to be an introduction to this complicated, many faceted subject.

Annex C
(informative)

Inspector's Checklist

The levels indicated in Table C.1 may be characterized as follows:

— Level 1 is typically used for pumps in general services,

— Level 2 comprises performance and material requirements and is more stringent than Level 1,

— Level 3 items should be considered for pumps in critical services.

The required inspection shall be indicated in the first column as:

— C: Certification only,

— O: Observed inspection,

— W: Witnessed inspection.

Table C.1—Inspector's Checklist

Inspection Required C, O, or W	Item	API 676 Subsection Number	Date Inspected	Inspected by	Status
	Level 1—Basic				
	Nozzle size, rating and finish [a]	6.4.3, 6.4.4, 6.6, 9.3.2.1			
	Casing jackscrews	6.3.5			
	Baseplate requirements	7.4			
	Certified hydrotest	8.2.1.2, 8.3.2			
	Performance within tolerance (certified)	8.3.4, 8.3.6			
	NPSH within tolerance (certified)	8.3.7.1, 8.3.6			
	Vibration within tolerance	6.11			
	Rotation arrow [a]	6.14.2			
	Overall dimensions and connection locations [a]	9.2.2.1, 9.2.2.2, 9.3.2.1			
	Anchor bolt layout and size [a]	9.2.2.1, 9.2.2.2, 9.3.2.1			
	Shaft and keyway dimensions [a]	9.2.2.1, 9.2.2.2			
	Equipment feet pilot holes	9.2.2.1, 9.2.2.2			
	Relief valve characteristics	6.3.2, 7.5			
	Special tools	7.9			
	Motors and electrical components area classification	6.1.10, 7.1.1, 7.1.2, 7.6			
	Piping fabrication and installation	6.5, 6.13.5			
	Equipment nameplate data	6.14			
	Restrained motor rotor [a]	Sleeve bearing motor			
	Storage preservation instructions	8.4			

[a] Check against certified dimensional outline drawing.

Table C.1—Inspector's Checklist (Continued)

Inspection Required C, O, or W	Item	API 676 Subsection Number	Date Inspected	Inspected by	Status
	Rust prevention	8.4.3.2 through 8.4.3.6, 8.4.3.9, 8.4.5			
	Painting	7.4.13, 8.4.3.1			
	Preparation for shipment	8.4			
	Shipping documents and tags	8.4.3.8			
	Level 2—Intermediate (Add to Level 1)				
	Copies of sub-vendor purchase order	9.1.3 a)			
	Material certification	6.13.2.10, 8.2.1.1 a)			
	NDE (components)	8.2.2			
	Hardness testing	6.13.2.13			
	Hydrotest witnessed	8.1, 8.2.1.2, 8.3.2			
	Building records (runouts, clearances)	6.8.1.5, 8.2.1.1 f)			
	Performance and NPSH tests witnessed	8.1, 8.3.4, 8.3.6, 8.3.7.1			
	Level 3—Special (Add to Levels 1 and 2)				
	Welding procedures approved	6.13.3.6			
	Welding repairs approved	6.13.3.6			
	Welding repair maps	6.13.3.6			
	Rotor balancing	6.8.1.9			
	Complete unit test	8.3.7.2			
	Sound level test	8.3.7.3			
	High discharge pressure test	8.3.7.4			

[a] Check against certified dimensional outline drawing.

Annex D
(informative)

Rotary Pump Vendor Drawing and Data Requirements (VDDRs)

ANNEX D - ROTARY PUMP VENDOR DRAWING & DATA REQUIREMENTS API 676 3rd Edition

JOB NO. ____________ **ITEM NO.** ______
PURCHASE ORDER NO. ____________ **DATE** ______
REQUISITION NO. ____________ **DATE** ______
INQUIRY NO. ____________ **DATE** ______

PAGE ____ **OF** ____ **BY** ____________

FOR ____________ **REVISION** ____________
SITE ____________ **UNIT** ____________
SERVICE ____________ **NO. REQUIRED** ____________

Proposal a — Bidder shall email pdf files of all items indicated by an X.

Review b — Vendor shall email pdf files of drawings and data indicated.

Final c — Vendor shall email pdf files of drawings and data indicated.
Vendor shall furnish ______ copies of operating and maintenance manuals / data books and _____ CD's of pdf files of same.

DISTRIBUTION RECORD

Final – Received from vendor
Final - Due from vendor c
Review – Returned from vendor
Review – Received from vendor
Review – Due from vendor c

Note: Mark through those items that will not be furnished & add items that will.

DESCRIPTION

Proposal a	Review b	Final c	**VDDR Note Ref. No.**	**PUMP**	Review – Due from vendor c	Review – Received from vendor	Review – Returned from vendor	Final - Due from vendor c	Final – Received from vendor
			D.1.1	Certified dimensional outline drawing					
			D.1.1	Allowable flange loadings (can be part of certified outline drawing)					
			D.1.2	Cross-sectional drawings and bills of materials					
			D.1.3	Mechanical seal drawing and bills of materials					
			D.1.9	Shaft coupling assembly drawing and bill of materials					
			D.1.4	Primary and auxiliary flush piping schematics and bills of materials					
			D.1.5	Cooling or heating schematic and bill of materials					
			D.1.10	Lubricating oil schematic and bill of materials					
			D.1.10	Lubricating oil system arrangement drawing					
			D.1.10	Lubricating oil component drawings					
			D.1.11	Electrical and instrumentation schematics, wiring diagrams, and bills of materials					
			D.1.12	Electrical and instrumentation arrangement drawing and list of connections					
			D.1.13	Tabulation of utility requirements					
			D.1.14	Pump speed torque curve					
				Performance curves					
			D.1.18	Vibration analysis data					
			D.1.19	Damped unbalanced response analysis					
			D.1.20	Lateral critical speed analysis					
			D.1.21	Torsional critical speed analysis					
			D.1.22	Certified hydrostatic test data					
			D.1.27	Material certifications					
			D.1.17	Weld procedures					
			D.1.25	Non destructive testing procedures					
			D.1.26	Performance and optional test procedures					
			D.1.24	Performance test data					
				Optional test data and reports					
				Certified rotor balance data					
				Residual unbalance check					
				Rotor mechanical and electrical runout for pumps with noncontacting vibration probes					
			D.1.28	Data sheets applicable to proposals, purchase and as-built					
				Noise data sheets					
			D.1.29	As-built clearances					
			D.1.30	Installation manual					
			D.1.31	Operation and maintenance manual					
			D.1.32	Spare parts recommendations and price list					
			D.1.33	Progress reports and schedules					
			D.1.34	List of drawings and submittals					
			D.1.35	Shipping list					
			D.1.36	List of special tools furnished					
			D.1.37	Technical data manual					
				DRIVER					
			D.2.1	Certified dimensional outline drawing					
			D.2.2	Cross-sectional drawing and bill of materials					
			D.2.3	Data sheets applicable to proposals, purchase and as-built					
			D.2.4	Noise data sheets					
			D.2.5	Performance data					
			D.2.6	Performance test data					
			D.2.7	Certified drawings of auxiliary systems					
			D.2.8	Installation operation and maintenance manuals					
			D.2.8	Spare parts recommendations					
				GEAR					
			D.2.1	Certified dimensional outline drawing					
			D.2.2	Cross-sectional drawing and bill of materials					
			D.2.3	Data sheets applicable to proposals, purchase and as-built					

ANNEX D - ROTARY PUMP VENDOR DRAWING & DATA REQUIREMENTS API 676 3rd Edition

JOB NO. ____________ **ITEM NO.** ____________
PURCHASE ORDER NO. ____________ **DATE** ____________
REQUISITION NO. ____________ **DATE** ____________
INQUIRY NO. ____________ **DATE** ____________

PAGE _____ **OF** _____ **BY** ____________
FOR ____________ **REVISION** ____________
SITE ____________ **UNIT** ____________
SERVICE ____________ **NO. REQUIRED** ____________

Proposal a — Bidder shall email pdf files of all items indicated by an X.

Review b — Vendor shall email pdf files of drawings and data indicated.

Final c — Vendor shall email pdf files of drawings and data indicated.
Vendor shall furnish ______ copies of operating and maintenance manuals / data books and _____ CD's of pdf files of same.

DISTRIBUTION RECORD

Final – Received from vendor
Final - Due from vendor c
Review – Returned from vendor
Review – Received from vendor
Review – Due from vendor c

Note: Mark through those items that will not be furnished & add items that will.

Proposal a	Review b	Final c		DESCRIPTION	Review – Due from vendor c	Review – Received from vendor	Review – Returned from vendor	Final - Due from vendor c	Final – Received from vendor
			D.2.4	Noise data sheets					
				Performance data					
				Performance test data					
			D.2.7	Certified drawings of auxiliary systems					
			D.2.8	Installation operation and maintenance manuals					
			D.2.8	Spare parts recommendations					

a Proposal drawings and data do not have to be certified or as-built. Typical data shall be clearly identified as such.
b Purchaser will indicate in this column the time frame for submission of materials using the nomenclature given at the end of this form
c Vendor shall complete these two columns to reflect his actual distribution schedule and include this form with his proposal

Email all drawings and data to ____

Ship final IOM's and Data books to: ____

All drawings and data shall show project, appropriation, purchase order, and item numbers in addition to the plant location and unit. In addition to the copies specified above, one set of the drawings/instructions necessary for field installation shall be forwarded with the shipment.

Nomenclature:
___ S — number of weeks prior to shipment.
___ F — number of weeks after firm order.
___ D — number of weeks after receipt of approved drawings.

Vendor: ______________________ Vendor Reference: ______________________
Date: ______________________

Note: Vendor and purchaser to mark out items that do not apply to this order and sign below.

Vendor Signature: ____

D.1 Pump

D.1.1 Reference Descriptions

1) Certified dimensional outline drawing and list of connections, including the following:

   a) size, rating, and location of all customer connections;

   b) approximate overall handling weights;

   c) overall dimensions;

   d) shaft centerline height;

   e) dimensions of baseplates (if furnished), complete with diameter, number, and locations of bolt holes and thickness of the metal through which the bolts must pass; centers of gravity; and details for foundation design;

   f) grouting details;

   g) forces and moments for suction and discharge nozzles;

   h) center of gravity and lifting points;

   i) shaft end separation and alignment data;

   j) direction of rotation.

2) Cross-sectional drawing and bill of materials, including the following:

   a) journal-bearing shaft and housing fits and tolerances;

   b) rolling element bearing shaft and housing fits and tolerances;

   c) shaft end details, fits and tolerances.

3) Mechanical seal drawings and bill of materials.

4) Primary and auxiliary sealing schematic and bill of materials, including seal fluid, fluid flows, pressure, pipe and valve sizes, instrumentation, and orifice sizes.

5) Cooling or heating schematic and bill of materials, including cooling or heating media, fluid flows, pressure, pipe and valve sizes, instrumentation, and orifice sizes.

6) Rotor assembly drawings and bills of materials, including the following items.

   a) Axial position from the active thrust-collar face to:

      i) each journal-bearing centerline,

      ii) coupling face or end of shaft.

   b) Thrust-collar assembly details, including:

      i) collar-shaft, with tolerance;

ii) concentricity (or axial runout) tolerance;

iii) required torque for locknut;

iv) surface finish requirements for collar faces;

v) preheat method and temperature requirements for shrunk-on collar installation.

7) Thrust-bearing assembly drawing and bill of materials.

8) Journal-bearing assembly drawings and bills of materials for all field-maintainable rotors.

9) Shaft-coupling assembly drawings and bills of materials, including the following:

a) hydraulic mounting procedure (if applicable),

b) shaft end gap and tolerance,

c) coupling guards.

10) Lube-oil schematic and bills of materials, including the following:

a) steady-state and transient oil flows and pressures at each use point;

b) control, alarm, and trip settings (pressures and recommended temperatures);

c) total heat loads;

d) utility requirements, including electricity, water, and air;

e) pipe, valve and orifice sizes;

f) instrumentation, safety devices, control schemes and wiring diagrams;

g) lubricating oil system arrangement drawing, including size, rating, and location of all purchaser connections;

h) lubricating oil component drawings and data, including the following:

i) pumps and drivers;

ii) coolers, filters and reservoir;

iii) instrumentation;

iv) spare parts lists and recommendations.

11) Electrical and instrumentation schematics and bills of materials for all systems. The schematics shall show the alarm and shutdown limits (set points) below:

a) vibration alarm and shutdown limits;

b) bearing temperature alarm and shutdown limits;

c) lubricating oil temperature alarm and shutdown limits;

d) driver.

12) Electrical and instrumentation assembly drawings and lists of connections.

13) Tabulation of utility requirements (may be on as-built purchaser datasheets).

14) Curve showing output-power shaft speed vs torque.

15) Anticipated thermal movements referenced to a defined point.

16) Coupling alignment diagram, including recommended coupling limits during operation. Note all shaft-end position changes and support growth from a reference ambient temperature of 15 °C (59 °F) or another temperature specified by the purchaser. Include the recommended alignment method and cold setting targets.

17) Welding procedures for fabrication and repair.

18) Vibration analysis data.

19) Damped unbalanced response analysis.

20) Lateral Critical Speed Analysis—The required number of lateral critical analysis reports, no later than three months after the date of order.

21) Torsional Critical Speed Analysis—The required number of torsional critical analysis reports, no later than three months after the date of order.

22) Certified hydrostatic test data/logs.

23) Mechanical running test logs.

24) Performance test logs and report.

25) Nondestructive test procedures as itemized on the purchase order datasheets or the VDDR form.

26) Procedures for any special or optional tests.

27) Certified mill test reports of items as agreed upon in the pre-commitment or pre-inspection meetings.

28) As-built datasheets.

29) As-built dimensions (including nominal dimensions with design tolerances) and data for the following listed parts.

a) Shaft or sleeve diameters at:

i) thrust collar (for separate collars),

ii) each seal component,

iii) each journal bearing.

b) Each labyrinth or seal-ring bore.

c) Thrust-collar bore (for separate collars).

d) Each journal-bearing inside diameter.

e) Thrust-bearing concentricity (axial run-out).

f) Metallurgy and heat treatment for:

i) shaft,

ii) rotors,

iii) thrust collar.

30) Installation manual describing the following:

a) storage procedures including winterization, tropicalization and/or noise attenuation details, if required;

b) foundation plan;

c) grouting details;

d) setting equipment, rigging procedures, component weights, and lifting diagrams;

e) coupling alignment diagram [per Item 13)];

f) piping recommendations, including allowable flange loads;

g) composite outline drawings for the driver/driven-equipment train, including anchor bolt locations;

h) dismantling clearances.

31) Operating and maintenance manuals describing the following items:

a) start-up;

b) normal shutdown;

c) emergency shutdown;

d) lube-oil recommendations;

e) routine operational procedures, including recommended inspection schedules and procedures;

f) instructions for:

i) disassembly and reassembly of journal bearings (for tilting-pad bearings, the instructions shall include "go/no-go" dimensions with tolerances for three-step plug gauges);

ii) disassembly and reassembly of thrust bearing;

iii) disassembly and reassembly of seals (including maximum and minimum clearances);

iv) disassembly and reassembly of thrust collar.

g) Performance data, including:

i) curve showing certified shaft speed vs site rated power,

ii) curve showing output-power shaft speed vs torque.

h) As-built data, including:

i) as-built datasheets;

ii) as-built dimensions or data, including assembly clearances;

iii) hydrostatic test logs, per Item 15);

iv) mechanical running test logs, per Item 16).

i) Drawings and data, including:

i) certified dimensional outline drawing and list of connections,

ii) cross-sectional drawing and bill of materials,

iii) rotor assembly drawings and bills of materials,

iv) thrust-bearing assembly drawing and bill of materials,

v) journal-bearing assembly drawings and bills of materials,

vi) seal-component drawing and bill of materials,

vii) lube-oil schematics and bills of materials,

viii) electrical and instrumentation schematics and bills of materials,

ix) electrical and instrumentation assembly drawings and list of connections.

32) Spare parts list with stocking level recommendations.

33) Progress reports and delivery schedules, including vendor buy-outs and milestones. progress reports detailing the cause of any delays: the reports shall include engineering, purchasing, manufacturing and testing schedules for all major components. Planned and actual dates, and the percentage completed, shall be indicated for each milestone in the schedule.

34) List of drawings, including latest revision numbers and dates.

35) Shipping list, including all major components that will ship separately.

36) List of special tools furnished for maintenance.

37) Technical data manual, including the following:

a) as-built purchaser datasheets, per Item 21);

b) certified performance curves, per Item17);

c) drawings;

d) as-built assembly clearances;

e) spare parts list;

f) utility data, per Item 13);

g) reports, per Items 17).

38) Material safety datasheets (OSHA Form 20).

D.2 Driver and Gear (if Applicable)

D.2.1 Reference Description

1) Certified dimensional outline drawing for motor and all auxiliary equipment, including the following:

a) size, location, and purpose of all purchaser connections, including conduit, instrumentation, and any piping or ducting;

b) ASME rating and facing for any flanged connections;

c) size and location of anchor bolt holes and thicknesses of sections through which bolts must pass;

d) total mass of each item of equipment (motor and auxiliary equipment) plus loading diagrams, heaviest mass, and name of the part;

e) overall dimensions and all horizontal and vertical clearances necessary for dismantling, and the approximate location of lifting lugs;

f) shaft centreline height;

g) shaft end dimensions, plus tolerances for the coupling;

h) direction of rotation.

2) Cross-sectional drawing and bill of materials, including the axial rotor float.

3) Datasheets applicable to proposals, purchase, and as-built.

4) Noise datasheets.

5) For induction motors 150 kW (200 hp) and smaller:

a) efficiency and power factor at one-half, three-quarter, and full load;

b) speed-torque curves.

6) For induction motors larger than 150 kW (200 hp) and larger, certified test reports for all test:

a) time-current heating curve;

b) speed-torque curves at 70 %, 80 %, 90 %, and 100 % of rated voltage;

c) efficiency and power factor curves from 0 to rated service factor;

d) current vs load curves from 0 to rated service;

e) current vs speed curves from 0 % to 100 % of rated speed.

7) Certified drawings of auxiliary systems, including wiring diagrams, for each auxiliary system supplied. The drawings shall clearly indicate the extent of the system to be supplied by the manufacturer and the extent to be supplied by others.

8) Driver instruction manuals describing installation, operating and maintenance procedures. Each manual shall include the following sections:

a) Section 1—Installation:

i) storage;

ii) setting motor, rigging procedures, component masses and lifting diagram;

iii) piping and conduit recommendations;

iv) composite outline drawing for motor, including locations of anchor-bolt holes;

v) dismantling clearances.

b) Section 2—Operation:

i) start-up, including check before start-up;

ii) normal shutdown;

iii) operating limits, including number of successive starts;

iv) lubricating oil recommendations.

c) Section 3—Disassembly and assembly instructions:

i) rotor in driver,

ii) journal bearings,

iii) seals,

iv) routine maintenance procedures and intervals.

d) Section 4—Performance data required.

e) Section 5—Datasheets:

i) as-built datasheets,

ii) noise datasheets.

f) Section 6—Drawing and data requirements:

i) certified dimensional outline drawing for motor and all auxiliary equipment, with list of connections;

ii) cross-sectional drawing and bill of materials;

iii) spare parts recommendations and price list;

iv) material safety datasheets.

Annex E
(informative)

Net Positive Suction Head (NPSH) vs Net Positive Inlet Pressure (NPIP)

E.1 General

Because centrifugal pumps and positive displacement pumps operate on entirely different principles, common usage has created two different ways to identify the pressures associated with them. In its simplest form, a centrifugal pump is a velocity generator, whereas the positive displacement pump is a flow generator. In the case of the centrifugal pump, the liquid to be pumped is directed into the center of a rotating impeller where it is guided by the impeller vanes and accelerated to a higher velocity. The casing surrounding the impeller then converts the high velocity into pressure. Because it is a velocity generator, if pressure is measured in units of liquid length, all units of measure become consistent. Velocity is measured in meters/second (feet/second) and discharge pressure is measured in meters (feet) of liquid (i.e. the pressure created by the height of a column of the liquid being pumped). This consistent use of units greatly simplifies pump calculations and allows the effects of certain liquid properties (e.g. relative density) to be ignored. For a centrifugal pump, the discharge pressure developed is a function of flow through the pump impeller. With decreasing flow (as in the case of increased system resistance), the centrifugal pump develops an ever increasing pressure up to the point defined as the shutoff head at zero flow. Shutoff head is normally the maximum pressure rise that a centrifugal pump can develop, but there are instances when the shutoff head is less than the maximum head generated by the pump.

By contrast, a rotary positive displacement pump does not generate energy solely by increasing fluid velocity. Instead these pumps convert rotary motion and torque into constant linear fluid motion and force, generating a fixed flow rate at the discharge connection. Positive displacement pumps have no theoretical discharge pressure limitation. They respond solely to the pumping system, and require system discharge control, usually in the form of a PLV, to prevent damage to the pump mechanism, the pumping system, and/or stalling of the driver. For a positive displacement pump, flow is a function of pump displacement and rpm.

Both types of pumps require sufficient fluid pressure at the inlet to prevent a release of dissolved gases and/or a change in the state of the pumped fluid from liquid to gas, except for MPPs. The term for pressure at the inlet is either NPSH or NPIP. To be consistent, the API standards for both centrifugal and rotary pumps, as well as the latest editions of the Hydraulic Institute standards, refer to the total suction head as NPSH rather than NPIP. Although the Hydraulic Institute indicates that NPSH is normally expressed in either kilopascals (pounds force per square inch) or meters (feet), the latest API standards refer to NPSH in meters (feet), the preferred unit terminology for both pump types, to avoid confusion.

Positive displacement pump manufacturers generally refer to NPIP, expressed in kilopascals (pounds force per square inch). ISO 16330 also uses the term NPIP rather than NPSH. NPSH or NPIP is indicated as either “available” (NPSHA or NPIPA) or “required” (NPSHR or NPIPR). The net positive inlet pressure available (NPIPA) is the absolute pressure above fluid vapor pressure at the pump inlet, and is determined as follows:

$$\text{NPIPA} = p_a + p_z - p_f - p_{vp}$$

where

p_a is the absolute pressure at surface of liquid, expressed in kilopascals (pounds force per square inch) at the the altitude of the installation;

p_z is the static head (+) or static lift (–), expressed in kilopascals (pounds force per square inch), for level of fluid above or below inlet;

p_f is the inlet line, valve, and fitting friction losses at maximum viscosity, expressed in kilopascals (pounds force per square inch);

p_{vp} is the fluid vapor pressure or gas dissolution pressure, expressed in kilopascals (pounds force per square inch);

NPIPR is a function of pump type, speed and viscosity of fluid pumped. The NPIPA must always be greater than NPIPR to prevent occurrence of cavitation.

Annex F
(informative)

Pulsation and Vibration Control Techniques

F.1 Definition of Design Analyses

The definition of the design analyses includes the following:

a) Analysis Approach 1: F.1.1,

b) Analysis Approach 2: F.1.2 and F 1.3.

The Analysis Approaches provided in this annex may not give sufficient accuracy if the following conditions apply:

— inlet flow velocities below 0.3 m/s (1 ft/s) or above 3 m/s (10 ft/s),

— the inlet liquid temperature is high enough that cavitation can be anticipated,

— the service has a critical hazard condition.

Annex E can provide an insight into the limitations.

F.1.1 Analysis Approach 1

F.1.1.1 The analytical study includes the design of a pump pulsation suppression device using proprietary and/or empirical analytical techniques to meet the pulsation levels specified in F.1.4 to F.1.6. This approach includes the study, good piping layout, good support/restraint principles, and adequate NPIP to design a pulsation solution.

NOTE When deciding which approach should be used, the purchaser should consider such things as horsepower, economics, piping layout, reliability, documentation requirements, and experience with similar pumps and installations.

F.1.1.2 The analytical study should also include a simplified analysis of the purchaser's piping system by the purchaser with frequency data from the vendor to determine critical piping lengths that may be in resonance with the acoustical excitation frequencies.

F.1.2 Analysis Approach 2 (Acoustical Simulation)

This approach involves pulsation control through the use of pulsation control devices developed using proven acoustical simulation techniques in conjunction with mechanical analysis of pipe runs and support systems (clamp design and spacing) to achieve control of vibration response. F.1.2.1, F.1.2.2, and F.1.2.3 should be considered.

F.1.2.1 Calculation of Peak-to-peak Pulsation Levels

For this calculation, operating conditions and pump pressure steps are chosen to yield the highest expected pulsation amplitudes throughout the piping system. Pulsation amplitudes are then compared to the levels identified in F.1.4.

F.1.2.2 Calculation of Pulsation-induced Shaking Forces (Unbalanced Forces)

These calculations predict the maximum pulsation-induced shaking forces and unbalanced pressure acting on the critical elements of the piping system, such as pulsation control devices, pulsation control device internals, vessels, closed-end headers, and the like.

F.1.2.3 Development of Piping Modifications

If the pulsation analysis indicates that pulsation levels and/or shaking forces are excessive, modifications to the pulsation control devices and/or piping systems will be made and the analysis continued until the system meets the guidelines defined in F.1.4 or other criteria as agreed upon by the purchaser and vendor.

F.1.3 Mechanical Review and Piping Restraint Analysis

A simple mechanical review shall be performed using span and vessel mechanical natural frequency calculations to avoid mechanical resonance. This review shall result in a table of various pipe sizes that indicates the maximum allowable span (based on the maximum pump operating speed) between piping supports as a function of pipe diameter, and the separation margin requirements of F.1.7.

In the piping design, when clamps are used to avoid mechanical resonance, the thermal flexibility effects and static stresses should also be considered. To accurately predict and avoid piping resonance, the supports and clamps must rigidly restrain the piping. The piping restraint is not considered to be rigid unless the restraints have either enough mass or stiffness sufficient to emulate a vibration node at the restraint and the pipe is attached to the restraint using clamps. This requirement is difficult to attain with overhead piping and/or the use of simple supports, hangers, and guides.

F.1.4 Maximum Allowable Pulsation Levels

For Analysis Approach 1 or 2, the peak-to-peak pulsation levels in the suction and discharge piping systems beyond the pulsation control devices shall not exceed the levels calculated by Equation (5) or Equation (6) which specify the allowable peak-to-peak pulsation level of each individual pulsation frequency component.

$$P_1 = 3500/(ID \times f)^{0.5} \tag{5}$$

Or, in USC units:

$$P_1 = 100/(ID \times f)^{0.5} \tag{6}$$

where

P_1 is the maximum allowable peak-to-peak pulsation level of individual pulsation frequency components, expressed in kPa (psi) (suction and discharge pulsation levels also must be limited to values that will not cause cavitation or relief valve lifting);

ID is the inside diameter of line pipe, in millimeters (inches);

f is the pulsation frequency, in Hertz, derived from Equation (7) below.

$$f = (rpm)n/60 \tag{7}$$

where

rpm is the pump speed;

n is 1, 2, 3...corresponding to the fundamental frequency and harmonics of the pump speed.

For multiple units in parallel, the purchaser and vendor shall consider and agree upon the additive effects of pulsation due to simultaneous operation of all pumps or the level of pulsation at a particular test point.

F.1.5 Inlet Pressure vs Liquid Vapor Pressure

Unless other wise specified, the minimum value of the suction complex pressure wave P_{min} at the inlet reference point shall not be lower than the highest liquid vapor pressure with a margin of 10 % as shown in Equation (8).

$$P_{min} > 1.1 \times P\mathrm{v} \tag{8}$$

where

$P\mathrm{v}$ is the highest liquid vapor pressure.

Results on the vendor's test rig shall be above this limit by at least an additional 10 %.

NOTE 1 The theoretical maximum amplitude of the suction pulsation occurs when the negative peak of the pulsation complex wave equals the average suction pressure minus the vapor pressure. Equation (8) provides for a margin of safety between the negative peak of pulsation and vapor pressure.

NOTE 2 Entrained and/or dissolved gases can also significantly alter the cavitation characteristics of liquids.

F.1.6 Pressure-limiting Valve (PLV) Protection

Unless otherwise specified, the margin of separation between the positive peak of the pulsation complex wave at the relief valve and the relief valve setting shall be 10 % of the maximum specified discharge pressure or 165 kPa (25 psi), whichever is greater.

F.1.7 Separation Margin Requirements for Piping Systems

Unless otherwise specified, to ensure that separation requirements are met, both of the following guidelines are to be used together to avoid coincidence of excitation frequencies with mechanical natural frequencies of the pump, pulsation suppression devices, and the piping system.

a) The minimum mechanical natural frequency of any manifold or pipe system element shall be designed to be greater than 20 % above the significant frequency of the unbalanced forces and the pocket passing frequency. In certain pump configurations, there can be significant excitation energy at higher orders of running speed and the system design shall take this into account. If the minimum mechanical natural frequency guideline is not met, or if there is significant excitation energy at higher orders, the separation margins as defined in Item b) shall be maintained.

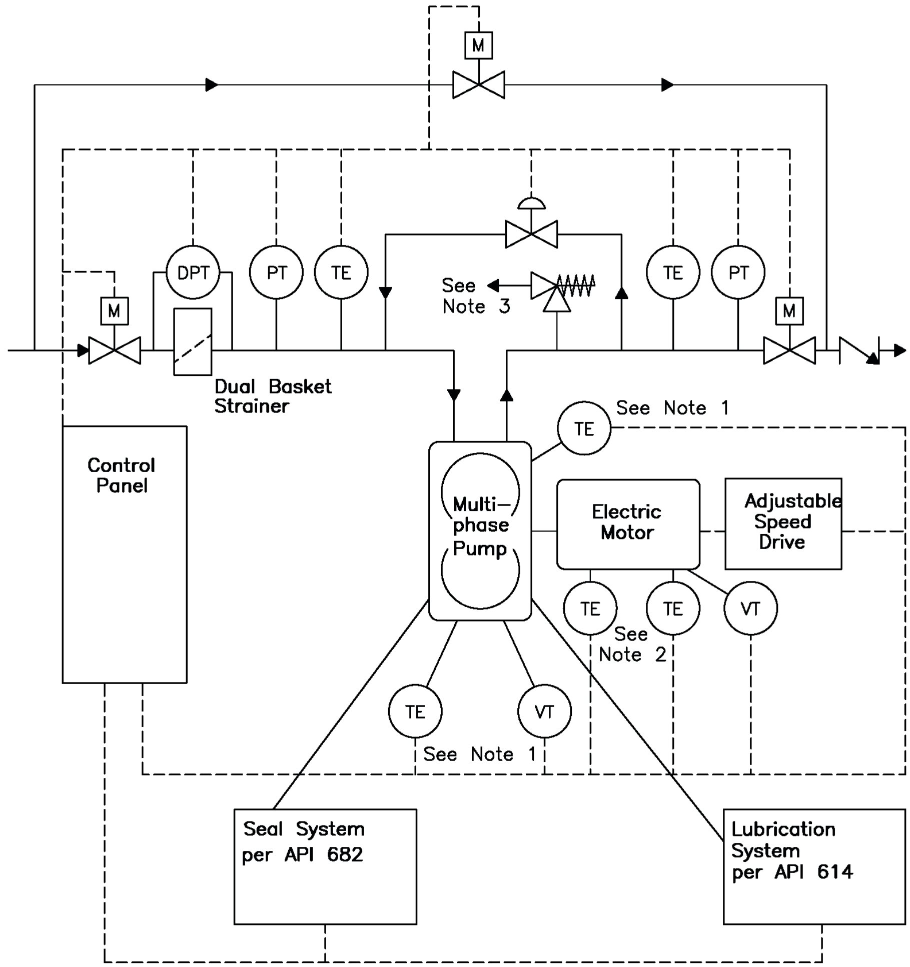
NOTE The intent is to prevent the mechanical natural frequencies of the piping system from being excited by forces generated by the pump.

b) The predicted mechanical natural frequencies shall be designed to be separated from significant excitation frequencies by at least 20 %.

NOTE The intent is that at least 10 % separation for the actual system is achieved, and, due to modeling limitations, if 20 % is used for predicted designs, then 10 % for the actual system will generally be attained.

Annex G
(informative)

Typical Piping and Instrumentation Diagram for Multiphase Pump (MPP) Skids



DPT is a differential pressure transmitter;

M is a motor actuated valve [other actuator types are available (i.e. hydraulic and pneumatic)];

PT is a pressure transmitter;

TE is a temperature element;

VT is a vibration transmitter.

NOTE 1 Pump TE covers bearings and fluid discharge.

NOTE 2 Motor TE covers windings and bearings.

NOTE 3 Discharge from the PLV shall be piped to a suction vessel, or header, or as far upstream of the skid as practical.

NOTE 4 Manual valves and small piping are not shown for clarity purposes.

Figure G.1—Typical Piping and Instrumental Diagram for Multiphase Pump (MPP) Skids

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